NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT
BIOLOGICAL OPINION

Agency: U.S. Environmental Protection Agency

Activity Considered: National Pollutant Discharge Elimination System Permit for the Washington Aqueduct
F/NER/2003/00600

Conducted by: National Marine Fisheries Service
Northeast Region

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Approved by: Patricia A Kurkul

This constitutes the National Marine Fisheries Service's (NOAA Fisheries) biological opinion (BO) on the impacts of the Environmental Protection Agency's (EPA) issuance of a revised National Pollutant Discharge Elimination System (NPDES) Permit for the Washington Aqueduct in the Potomac River in the District of Columbia (DC) on threatened and endangered species in accordance with Section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.). This BO is based in part upon NOAA Fisheries' independent evaluation of the following: information provided in the EPA's biological evaluation (BE), the Army Corps of Engineers (ACOE) report entitled Water Quality Studies in the Vicinity of the Washington Aqueduct (EA Engineering, Science, and Technology, Inc. 2001), the Woodrow Wilson Bridge Biological Assessment, the U.S. Fish and Wildlife Service (FWS) 1999 report of panel recommendations, and other sources of information. A complete administrative record of this consultation will be kept at the NOAA Fisheries Northeast Regional Office. Formal consultation was reinitiated on May 21, 2003. The BO signed on November 5, 2002, on the effects of a previous version of the NPDES permit that EPA did not issue is hereby withdrawn.

BACKGROUND

The Washington Aqueduct is a facility owned and operated by the ACOE and has been supplying water since 1859. Currently, it provides water to three wholesale customers (the Customers) located in two areas in Virginia and one in the District of Columbia. The Customers provide potable water for approximately one million citizens.

As part of its normal operations, historically, the Aqueduct has periodically discharged sediments into the Potomac River near Little Falls. Consequently, the ACOE is required to have a NPDES permit (issued by the EPA) to operate the Aqueduct. The Aqueduct currently operates under a NPDES permit that was issued on March 14, 2003 and became effective on April 15, 2003. Concerns about the effect of the Aqueduct's sediment discharges on water quality, fish and other aquatic life have been debated since the previous permit was issued in 1989. In 1993, the ACOE funded a study to investigate the potential adverse effects associated with the sediment discharges on a variety of test organisms. In 1993, Dynamac Corporation prepared the final report for this study and concluded that there were no adverse effects to the test organisms from any aspect of the sediment discharges. The results of this study have been questioned, however, due to concerns over the study design and data analysis. For example, the number of sampling sites and replicates were limited, and eggs and juveniles were not subjected to the tests.

In 1995, Aqueduct engineers investigated alternatives to river disposal of the sediment. In early 1995, EPA prepared a draft NPDES permit for public comment, which included a land-based disposal method and effluent limitations. The Customers, local residents, and the ACOE expressed significant concerns over the conditions of this permit. The ACOE and the Customers were concerned that the proposed permit would require the Aqueduct to construct and operate an expensive residual solids recovery facility that was beyond their ability to finance. They also believed that the need for the solids recovery facility had not been demonstrated based upon the water quality study performed by the Dynamac Corporation. These concerns were brought to the attention of the U.S. Congress and a letter ensued requesting EPA to delay the issuance of the permit, pending resolution of the Customer's concerns. Congressional concern was also evidenced by an amendment to the Safe Drinking Water Act that requires EPA to consult with the Customers prior to issuing the NPDES permit. Citizen groups, including the Western Avenue Citizen's Group and the Coalition for the Responsible Urban Disposal at Dalecarlia were concerned that the limits in the proposed permit would require increased truck traffic through their neighborhoods. In addition to increased vehicular traffic, citizen groups were also concerned about the potential for noise, lack of citizen input and degradation of air quality. Also at that time, the NPS was unwilling to allow this traffic on park roads. Some commercial and recreational users of the river supported the permit limits because they believed that the sediment releases were unaesthetic and detrimental to the health of the river.

While concerns about the Aqueduct discharges on aquatic life in general have existed for some time, there were no known concerns for ESA listed species until 1996. Prior to 1996, because of the lack of documented captures of shortnose sturgeon in the Potomac River, it was thought that this species had been extirpated from the Potomac. Therefore, consultation pursuant to Section 7 of the ESA on the effects of a federal action on shortnose sturgeon in the Potomac River was not warranted. In 1996, the FWS began an Atlantic Sturgeon Reward Program in Maryland waters. In the first year of the Reward Program, one shortnose sturgeon (*Acipenser brevirostrum*) was unexpectedly captured and positively identified in the Potomac River (on May 17). This was the first report of a shortnose sturgeon being taken in the Potomac since 1899. As of March 2003, a total of six shortnose sturgeon have been captured and documented through the Atlantic Sturgeon Reward Program from the Potomac River (May 17, 1996; April 21, 1998; May 3, 2000; March 26, 2001; and two on March 8, 2002).

In 1997, the ACOE, EPA, and the Customers agreed to undertake a three-year water quality study to determine the effects of the Aqueduct's discharges on habitat, water quality, and living resources, including shortnose sturgeon. The EPA determined at that time that the new NPDES permit could not be issued until the study of the effects of the discharges was completed. Through an Interagency Agreement with FWS, EPA created and funded a panel of fisheries biologists from the FWS, NOAA Fisheries, Maryland Department of Natural Resources (MD

DNR), DC Fish and Wildlife, and the Interstate Commission on the Potomac River Basin. This panel was convened, in 1998, in order to recommend short-term measures to minimize impacts to migratory fish from sediment discharges at the Washington Aqueduct. The result of this meeting was a report issued in March 1999 describing the potential impacts of the discharges and providing recommendations on measures to minimize those impacts. In this report, it was stated that due to the potential for discharges to affect shortnose sturgeon in the Potomac River, NOAA Fisheries would be recommending that EPA initiate Section 7 consultation on the issuance of a NPDES permit for the Aqueduct discharges.

CONSULTATION HISTORY

In spring 2001, EPA and NOAA Fisheries entered into informal Section 7 consultation. In October 2001, EA Engineering, Science, and Technology, Inc. published a final report entitled *Water Quality Studies in the Vicinity of the Washington Aqueduct*. The EPA used this report to develop a BE to assess the impacts of the discharges on shortnose sturgeon. NOAA Fisheries provided comments to EPA on the contents of the BE, and a final draft was provided to NOAA Fisheries on June 13, 2002. In the BE, EPA concluded that the issuance of the NPDES permit for the Washington Aqueduct was not likely to adversely affect shortnose sturgeon. This determination was based on EPA's opinion that the scientific studies performed to date had shown that the conditions contained in the draft permit were protective of aquatic species present in the action area and their habitat and the DC Water Quality Standards. It was also EPA's contention that the issuance of the draft permit was the first step in an overall plan to significantly reduce or eliminate Aqueduct discharges from the Potomac River.

The draft permit prohibited discharges annually from February 15 through June 15 (the spring spawning season) in order to protect anadromous species. The ACOE indicated that, in the past, the spring was typically the time when discharges occurred most frequently due to the high river flows. As such, the ACOE indicated that conditions could require discharges during the prohibited spring spawning season, which would require invoking the bypass provision in the permit. Because shortnose sturgeon are likely present and spawning in the vicinity of the Aqueduct outfalls during the spring, NOAA Fisheries determined that this action may adversely affect shortnose sturgeon. Therefore, in a conference call on May 29, 2002, NOAA Fisheries recommended that EPA initiate formal consultation. This recommendation was based on NOAA Fisheries' determination that the discharges may affect shortnose sturgeon eggs and larvae.

In a letter to NOAA Fisheries, dated June 13, 2002, EPA requested the initiation of formal consultation on the issuance of a NPDES permit for the Washington Aqueduct discharges. In a separate letter to NOAA Fisheries, also dated June 13, 2002, EPA indicated that for the purposes of the consultation, EPA will continue to be the designated lead Federal agency. On July 9, 2002, NOAA Fisheries concurred and informed the EPA that the date of the June 13, 2002 letter would serve as the commencement of the formal consultation process. Formal consultation culminated in the issuance of a BO on November 5, 2002. The BO concluded that issuance of the March 2002 draft permit may adversely affect shortnose sturgeon eggs and larvae but was not likely to jeopardize the continued existence of the Chesapeake Bay distinct population segment of the shortnose sturgeon. It also concluded that the proposed project was not likely to adversely affect juvenile or adult shortnose sturgeon present in the vicinity of the Aqueduct discharge outfalls. No critical habitat has been designated for this species, and therefore, none would be affected.

Due to the high level of public interest in this matter, EPA decided to modify the permit and resubmit it for public comment. On December 18, 2002, EPA issued the revised draft permit for public comment. The revised draft permit includes tighter controls on the discharge of the residual solids and incorporates some of the Reasonable and Prudent Measures (and Terms and Conditions) of the November 5, 2002 BO. The revised draft permit includes effluent limits on total suspended solids (TSS), total aluminum concentrations, and chlorine and immediate compliance with these conditions is required upon issuance of the final permit. The EPA and the ACOE will enter into a Federal Facility Compliance Agreement (FFCA) in order to allow the ACOE time to install the necessary measures to ensure that the Aqueduct can comply with the numeric effluent limitations included in the permit.

In a letter dated January 7, 2003, NOAA Fisheries provided comments to EPA on the revised draft permit and revised BE and requested additional information. NOAA Fisheries stated that this information was necessary in order to make a determination on whether to recommend that Section 7 consultation be reinitiated or that the existing BO be amended to reflect the changes in the permit. EPA agreed to make the modifications suggested by NOAA Fisheries, and on February 3, 2003, submitted the final revised BE via electronic mail. In subsequent conversations with EPA and the ACOE, it was determined that the suggested modification that included utilizing cultured shortnose sturgeon for the toxicity and the TSS studies was not feasible. As such, on February 24, 2003, NOAA Fisheries requested that EPA again revise the BE to reflect this change. EPA complied and submitted a revised final BE on February 24, 2003.

EPA and NOAA Fisheries participated in a number of conference calls during which the FFCA and the implementation of the NPDES permit were discussed. On February 24, 2003, EPA supplied NOAA Fisheries with a draft of the FFCA. Through these discussions, NOAA Fisheries was able to gather and review the information necessary to make a determination of the most appropriate manner in which to proceed with consultation. This information included reports pertaining to the operations of the Washington Aqueduct, the revised NPDES permit, a fact sheet, BE, and draft FFCA. NOAA Fisheries determined that the modifications made to the permit and the process by which the Washington Aqueduct will comply with the permit have resulted in significant changes to the proposed action and impact the analysis of the effects of the action on shortnose sturgeon that was included in the November 5, 2002 BO. Therefore, in a letter to EPA dated March 3, 2003, NOAA Fisheries recommended that consultation be reinitiated as conditions necessary to require reinitiation have been triggered. The proposed action to be considered during reinitiation has been defined as the issuance of the revised NPDES permit and the FFCA. On March 4, 2003, the ACOE announced that they would voluntarily refrain from discharging through June 15, 2003 in order to protect the spring spawn. Because EPA thought it was important to issue the permit as quickly as possible to protect the 2003 fish spawning season, the permit was issued on March 14, 2003, and the decision was made by EPA to complete consultation after the permit was issued. EPA stated that they could take this course of action in accordance with Section 7(d) of the ESA. Formal consultation with EPA was reinitiated on May 21, 2003. In a letter dated June 12, 2003, EPA requested that NOAA

Fisheries consider additional modifications to the March 14 permit as part of the action under consultation. These changes include an extension of the spring spawning season to characterize the period from February 15 to June 30 each year. In addition the requirement for EPA to perform a habitat study (Part III.D.I of March 14 permit), requirement to hold fish for the performance of a DNA study (Part III.D.2 of March 14 permit), and, requirement to perform a soil characterization study (Part III.D.5 of March 14 permit) were removed from the permit as these studies will now be conducted by the Department of Interior with assistance from NOAA Fisheries.

DESCRIPTION OF THE PROPOSED ACTION

The Clean Water Act (CWA) requires that all facilities that discharge pollutants from a point source into the waters of the United States are required to obtain a NPDES permit. In accordance with the provisions of the CWA, EPA is the permitting authority responsible for issuing NPDES permits in the District of Columbia. A permit is typically a license for a facility to discharge a specified amount of a pollutant into a receiving water under certain conditions. The proposed action under consideration is the issuance of a revised NPDES permit and FFCA for the Washington Aqueduct facility. The NPDES permit (DC0000019) will expire five years from the effective date.

The Washington Aqueduct produces drinking water for approximately one million citizens in DC, Arlington, Virginia, and Falls Church, Virginia. The Baltimore District ACOE owns and operates this facility, which produces an average of 180 million gallons of water per day at two treatment plants located in DC (the Dalecarlia and McMillan Water Treatment Plants).

Raw river water is obtained for both plants from the Great Falls Raw Water Intake or the Little Falls Pumping Station on the Potomac River (See Appendix A). Pumped raw water settles at the Dalecarlia Reservoir, where currently, approximately 51 percent of the solids are removed. The water then flows from the Dalecarlia Reservoir to settling basins at either the Dalecarlia plant or the Georgetown Reservoirs for additional settling and treatment. After raw water is withdrawn from the river, aluminum sulfate (alum), a settling agent, is added to remove the suspended solids present in the raw water. When the alum mixes with the water, aluminum hydroxide is created. The aluminum hydroxide binds with the suspended solids causing them to precipitate out of the solution as a visible flocculent. The discharge of aluminum bearing sediments to the Potomac River takes place at three outfalls identifed in the permit as Outfall 002, 003, and 004. Outfall 002 is the discharge point for the four sedimentation basins located at Dalecarlia. Outfalls 003 and 004 are the discharge points for the two sedimentation basins located at Georgetown. At both Dalecarlia and Georgetown, the liquid portion of the basins is decanted first in a process that takes anywhere from four hours for the smallest basin to 12 hours for the largest basin. This decanting is then followed by a release of the solid portion of the discharge which consists of sediment, aluminum sulfate and organic material that was present in the raw water. Flushing the basins with hosed water assists the release of solids. At Dalecarlia, finished water is used, which may contain chlorine. As such, the final permit requires monitoring of the effluent for chlorine and prohibits the discharge of chlorine. For this permit, EPA has defined no discharge as equal to or greater than 0.1 mg/l. At Georgetown, raw river water that does not contain chlorine is used for flushing. In a year with normal average rainfall, each Dalecarlia basin is emptied of treated sediments four times per year, and sediments from Georgetown Basin 2 are removed twice per year and sediments from Basin 1 are removed three times per year. Discharges from Outfall 006 consist of treated river water blowoff which is discharged once per year for the purpose of inspecting the City Tunnel. The average annual flow is one million gallons per year. These discharges are authorized by the NPDES permit issued by EPA.

The final permit issued on March 14, 2003 modifies the following conditions of the permit issued in 1989:

- The final permit combines former permit numbers DC000329 and DC0000019.

- The final permit adds a requirement to monitor for chlorine in the discharge of the Dalecarlia sedimentation basins and treated water blow off through Outfalls 002, 006 and 007, and establishes a no discharge limit for chlorine. For the purpose of this permit, EPA defines no discharge as equal to or greater than 0.1 mg/l. Since chlorinated water is not used to flush the Georgetown sedimentation basins, EPA has not required monitoring for or limits for chlorine at Georgetown.

- There shall be no direct discharge of the contents of the sedimentation basins through Outfalls 002, 003 or 004, during the spring spawning season, which the permit defines as February 15 through June 30 each year. The basis for this water quality-based effluent condition is the narrative portion of the District of Columbia Water Quality Standards. In addition, the 1999 Fisheries Panel Report and the 1993 Dynamac Study recommend the prohibition and the *2001 Water Quality Study* supported it.

- The final permit contains technology-based effluent limits (30 mg/l average monthly and 60 mg/l maximum daily) for total suspended solids (TSS) on Outfalls 002, 003 and 004. The basis for technology-based limits is Best Conventional Control Technology (BCT) which is applicable to TSS. Available technology should easily meet these limits.

- The final permit contains technology-based effluent limits for aluminum (4 mg/l average monthly and 8 mg/l maximum daily) on Outfalls 002, 003 and 004. In addition, EPA performed a reasonable potential analysis for metals, and it was determined that aluminum was the only metal that had a potential to exceed water quality standards. EPA calculated a water quality-based limit of 5 mg/l average monthly and 8 mg/l maximum daily. However, since the technology-based limit is more stringent, the technology-based limit applies. Best Available Technology (BAT) is the basis for technology-based limits for aluminum. (EPA has not promulgated guidelines governing drinking water plant discharges. Permitting authorities may apply Best Professional Judgement (BPJ) to establish BCT and BAT. To support its analysis relied in part on a survey of technologies commonly used at drinking water treatment plants in Region III and many states.)

- Using a combination of engineering and/or Best Management Practices, the permit requires the permittee to increase the amount of incoming residual solids removed from the Dalecarlia and Georgetown sedimentation basins to a minimum of 85%. The percent removal means the permittee must remove 85% of the flocculent and process water residual solids that enter the sedimentation basins. This percent removal is consistent with guidelines for identifying limits in effluent limit guidelines and is also consistent with EPA's removal efficiencies for municipal dischargers.

- Permittee must record surface, mid-depth and bottom water temperatures 24 hours before an anticipated discharge or within 24 hours of an unanticipated discharge during the shortnose sturgeon spawning season. Based on information provided in the November 5, 2002 BO, the shortnose sturgeon spawning season is defined as the period from March 1 through May 15 of each calendar year or when water temperatures are between 8 and 15 °C.

- The permit updates the administrative penalty provisions.

- The final permit contains a requirement to send Discharge Monitoring Reports (DMRs) to other government agencies, besides EPA, and notification in the event of an anticipated or unanticipated bypass or upset during the spring spawning season.

- The permit requires development and implementation of a Best Management Practices Plan. EPA carried over this requirement from the former permit DC0000329.

- The permit prohibits the permittee from discharging dredged material from the Dalecarlia Reservoir into the Potomac River.

- In the event it is determined that it is necessary to remove the rocks from the vicinity of Outfall 002 to ensure a controlled and measurable rate of sediment discharge, within six months of that determination, the permittee shall consult with and apply for a permit(s) from the National Park Service.

- Permittee must perform ichthyoplankton sampling immediately before, during and after a bypass/upset during the shortnose spawning season.

- Permittee may petition to modify the permit to remove the prohibition to discharge during the spring spawning season if it can show that it is meeting its numerical effluent limitation conditions and that they are sufficiently protective of the spring spawn.

The permit issued on March 14, 2003 also included the following special conditions (D1 through D5) which relate to additional studies that the permittee is charged with performing.

- (D1). In consultation with the NMFS, the permit requires the permittee to conduct a study to determine to what extent shortnose sturgeon use the area in the vicinity of Little Falls for spawning.

- (D2). To the extent possible, any shortnose sturgeon captured as a result of the Little Falls habitat study will be held alive for examination by NMFS or other designated personnel, for the collection of tissue samples for nuclear DNA analysis or other scientific examination.

- (D3). In consultation with NMFS and EPA, the permittee must perform additional acute and chronic toxicity studies. The studies shall include testing on Ceriodaphnia and 1 - 7 day old fathead minnows for the acute tests. Studies shall include the study of sediment toxicity above and below each outfall. If 25% or more of any acute or chronic toxicity test series with any test species on an individual outfall occurs within one year of testing, the ACOE will prepare and submit to EPA a plan for conducting a Toxicity Identification Evaluation (TIE) of that discharge. The ACOE will then conduct TIE testing for each discharge of that outfall for the following year. As part of EPA's consultation with NMFS, EPA intends to discuss modifying this permit provision to include the following requirement: If the habitat studies show that shortnose sturgeon are in the vicinity of Little Falls, in consultation with NMFS, the permittee will conduct toxicity studies using commercially available shortnose sturgeon.

- (D4). In consultation with EPA and NMFS, the permit requires permittee to perform a study to determine the effect of solids (settleable solids, suspended solids and depositional sediment) on fish growth and spawning success. This study will include testing the effects of solids on egg and larval stages of surrogate species. As part of EPA's consultation with NMFS, EPA intends to discuss modifying this permit provision to include the following requirement: If, as a result of the habitat study, shortnose sturgeon are found to be present in the vicinity of Little Falls, the permittee will conduct additional solids studies using commercially available shortnose sturgeon.

- (D5). Permittee shall submit a plan to EPA to describe how it will perform a soil sampling study to characterize the75 foot channels on National Park Service Property in which effluents from Outfalls 003 and 004 flow. Upon EPA approval of the plan, permittee shall implement the plan according to the plan schedule.

Through coordination with the appropriate cooperating agencies, it was determined that it was necessary to modify the permit to either provide clarification or remove several of these studies from the permit as they were slated to receive funding through other sources or were being performed by other agencies and were therefore an unnecessary duplication of effort. The National Park Service (NPS) has agreed to fund a study by the US Geological Survey (USGS) and FWS on shortnose sturgeon in the Potomac River. NOAA Fisheries is also contributing to this effort. The main objectives of the study are to determine the seasonal movements and relative abundance of shortnose sturgeon in the Potomac, to identify spawning areas and characteristics within the river, and characterize the genetics of shortnose sturgeon captured in the Potomac. Therefore, in order to avoid a duplication of effort, the first two studies described above (D1 and D2) are being removed from the permit. EPA also intends to modify D3 to provide clarification. The modifications include the following: performing chronic tests on both species identified four times per year rather than conducting toxicity tests for each discharge as this was deemed to be excessive; adding an additional acute test utilizing striped bass larvae in order to look at the effects on a potentially more sensitive species and modifying this test from the original study design regarding aeration techniques in order to achieve higher control survival; and for chronic testing, subjecting test organisms to the whole effluent for approximately 48 hours and then removing them and placing them in Potomac River water for the duration of the study exposure in order to more accurately mimic true discharge conditions. The cooperating agencies agreed that special condition D4 could be amended and only be required if the ACOE were to discharge under the bypass or upset conditions of the permit since this is the only time when larval fish would be affected by an Aqueduct discharge. The ACOE agreed to develop a study plan within three months of a bypass/upset discharge or prior to the spring spawning season following the bypass/upset discharge. Special condition D5 will be removed from the permit as the NPS has agreed to fund and conduct the study.

Under the March 14, 2003 permit, the Aqueduct is prohibited from discharging from February 15 through June 15. This time period was developed to ensure the protection of all anadromous fish species spawning in the Potomac during the spring, including shortnose sturgeon. However, the FWS has indicated that they have strong scientific evidence to suggest that the spring spawning season should be extended to June 30 to protect the larvae of several sensitive anadromous species. The ACOE and EPA have agreed that this is feasible. As a result, the final permit will be modified to extend the spring spawning season from February 15 through June 30.

As indicated, shortnose sturgeon are expected to be in the vicinity of the Aqueduct outfalls only during the spring spawning season (from the beginning of March through mid-May depending on water temperature). The prohibition of sediment release during the spring spawning season is a major departure in permitting for the Aqueduct. In past permits, the Aqueduct was encouraged to release sediments during the high river flows in the spring. The spring is also the time that the ACOE prepares for the peak summer production period by emptying and cleaning the basins to maximize the storage capacity as summer is historically dry in the Mid-Atlantic states. As such, the ACOE has indicated that unexpected conditions could arise during this prohibited time period that would necessitate invoking the bypass provision included in the Aqueduct permit. Under extreme conditions, this provision enables the permitee to discharge during the prohibited time period if there is the potential for loss of life or severe property damage. The bypass is considered a violation of the permit. However, EPA is responsible for determining whether the situation in which the bypass provision was invoked was necessary and if so, EPA has the ability to authorize the violation. The ACOE has stated that this is not expected to occur more than one time during the five-year duration of the permit (Pers. Comm. Tom Jacobus 2002). It is anticipated that a spring discharge will result in effects to shortnose sturgeon eggs, larvae, and adult fish. Therefore, the effects on these life stages from a single Aqueduct discharge over the 5-year life of the permit, which occurs during the spring spawning season, will be analyzed.

To allow the ACOE to meet its obligations under the National Environmental Policy Act (NEPA), EPA intends to enter into an FFCA with the ACOE. The FFCA includes the following provisions:

- Other than the numeric discharge limitations described in Parts I.A., B, C and D of the permit, the permittee will immediately comply with all provisions of the issued permit (including the prohibitions on discharges during the spring spawning season).

- The permittee will take any and all necessary steps within its power to achieve compliance with the numeric discharge limits set forth in the NPDES permit as soon as practicable, consistent with the permittee's obligations pursuant to NEPA.

- No later than May 28, 2004, the ACOE shall complete an alternatives evaluation and a disposal study. The purpose of the alternatives evaluation and disposal study shall be to identify a range of engineering and/or best management practices that will cause the discharge from the Washington Aqueduct to achieve compliance with the numeric discharge limitations set forth in the NPDES Permit.

- No later than December 20, 2004, the Corps shall complete and submit to EPA an analysis of engineering and/or best management practices that will cause the discharge from the Washington Aqueduct to achieve compliance with the numeric discharge limitations set forth in the NPDES Permit.

- No later than June 3, 2005, the Corps shall identify in a notice to EPA the engineering/best management practices it will implement in order to achieve compliance with the numeric discharge limitations set forth in the NPDES Permit and a schedule for implementing the identified engineering/best management practices as expeditiously as practicable, consistent with best engineering judgment.

- No later than December 30, 2009, the permittee shall have fully implemented all engineering/best management practices and shall achieve compliance with the numeric discharge limitations for all basins set forth in the permit.

- Until the permittee has fully implemented all engineering/best management practices and achieved compliance with the numeric discharge limitation set forth in the permit, the permittee will not discharge through Outfall 002 (discharge from Dalecarlia sedimentation basins numbered 1, 2, 3 and 4), unless the flow in the Potomac River is equal to or greater than 800 million gallons per day (MGD) as measured at the gauge station at Little Falls, and through Outfall 003 (discharge from Georgetown sedimentation basin number 1) and Outfall 004 (discharge from Georgetown sedimentation basin number 2), unless the flow in the Potomac River is equal to or greater than 1500 million gallons per day (mgd) as measured at the gauge station at Little Falls.

- Until the permittee has fully implemented all engineering/best management practices and achieved compliance with the numeric discharge limitations set forth in the permit, the permittees will slow the flocculent/sediment discharge rate from Outfalls 003 and 004 to a minimum of 36 hours per basin. In addition, the permittee will increase the amount of untreated process water that it uses to flush and clean each of the Georgetown sedimentation basins to twice the amount used for each cleaning in calendar year 2001.

- During an upset or bypass that occurs during the spring spawning season, the ACOE will use best efforts to slow the rate of discharge from Outfalls 003 and 004 to 72 hours per basin.

Action Area
The action area for this consultation includes the Potomac River from below the Little Falls area (immediately upstream of Chain Bridge) to upstream of Key Bridge in the District of Columbia (see Appendix A).

The tidally influenced portion of the Potomac River is approximately 182 km and extends from Little Falls to the mouth of the river near Point Lookout, Maryland and Smith Point, Virginia. In early autumn, the maximum upstream penetration of the "salt wedge" is approximately at Potomac River Mile (PRM) 80 which is located just above Gunston Cove. Throughout the remainder of the year, except during high flows in March and April when it is slightly farther downstream, the salt wedge is located at approximately PRM 70-75 (U.S. Federal Highway Administration 2000).

Shortnose sturgeon and many other species of sturgeon depend on free-flowing rivers and seasonal floods to provide suitable spawning habitat. For shortnose sturgeon, spawning grounds have been found to consist mainly of gravel or rubble substrate in regions of fast flow. This flowing water provides oxygen, allows for the dispersal of eggs, and assists in excluding predators. Seasonal floods scour substrates free of sand and silt, which might suffocate eggs (Beamesderfer and Far, 1997). The habitat near Little Falls, in the vicinity of the Aqueduct outfalls, is consistent with the spawning conditions preferred by shortnose sturgeon.

STATUS OF AFFECTED SPECIES

This section will focus on the status of the species within the action area, summarizing information necessary to establish the environmental baseline and to assess the effects of the proposed action.

The only endangered or threatened species under NOAA Fisheries' jurisdiction in the action area is the endangered shortnose sturgeon (*Acipenser brevirostrum*). No critical habitat has been designated for shortnose sturgeon.

Shortnose Sturgeon
Distribution
Shortnose sturgeon occur in large rivers along the western Atlantic coast from the St. Johns River, Florida (possibly extirpated from this system), to the Saint John River in New Brunswick, Canada. The species is anadromous in the southern portion of its range (i.e., south of Chesapeake Bay), while northern populations are amphidromous (NOAA Fisheries 1998). Population sizes vary across the species' range. From available estimates, smallest populations occur in the Cape Fear (~8 adults; Moser and Ross 1995) and Merrimack Rivers (~100 adults; M. Kieffer, United States Geological Survey, personal communication), while the largest

populations are found in the Saint John (~100,000; Dadswell 1979) and Hudson Rivers (~61,000; Bain et al. 1998). No reliable estimate of the size of the total species nor the shortnose sturgeon population in the Northeastern United States exists.

Total instantaneous mortality rates (Z) are available for the Saint John River (0.12 - 0.15; ages 14-55; Dadswell 1979), Upper Connecticut River (0.12; Taubert 1980b), and Pee Dee-Winyah River (0.08-0.12; Dadswell et al. 1984). Total instantaneous natural mortality (M) for shortnose sturgeon in the lower Connecticut River was estimated to be 0.13 (T. Savoy, Connecticut Department of Environmental Protection, personal communication). There is no recruitment information available for shortnose sturgeon because there are no commercial fisheries for the species. Estimates of annual egg production for this species are difficult to calculate because females do not spawn every year (Dadswell et al. 1984). Further, females may abort spawning attempts, possibly due to interrupted migrations or unsuitable environmental conditions (NOAA Fisheries 1998). Thus, annual egg production is likely to vary greatly in this species.

Habitat and Life History

Shortnose sturgeon are benthic fish that mainly occupy the deep channel sections of large rivers. They feed on a variety of benthic and epibenthic invertebrates including molluscs, crustaceans (amphipods, chironomids, isopods), and oligochaete worms (Vladykov and Greeley 1963; Dadswell 1979 *in* NOAA Fisheries 1998). Shortnose sturgeon are long-lived (30 years) and, particularly in the northern extent of their range, mature at late ages. In the north, males reach maturity at 5 to 10 years, while females mature between 7 and 13 years.

In the northern extent of their range, shortnose sturgeon exhibit three distinct movement patterns. These migratory movements are associated with spawning, feeding, and overwintering activities. In spring, as water temperatures rise above 8°C, pre-spawning shortnose sturgeon move from overwintering grounds to spawning areas. Spawning occurs from mid/late March to mid/late May depending upon location. In populations that have free access to the total length of a river (e.g., no dams within the species' range in a river: Saint John, Kennebec, Altamaha, Savannah, Delaware, and Merrimack Rivers), spawning areas are located at the farthest accessible upstream reach of the river, often just below the fall line (NOAA Fisheries 1998). Shortnose sturgeon spawn in upper, freshwater sections of rivers and feed and overwinter in both fresh and saline habitats. Shortnose sturgeon are believed to spawn at discrete sites within the river (Kieffer and Kynard 1996). In the Merrimack River, males returned to only one reach during the four years of the telemetry study (Kieffer and Kynard 1996). Squires (1982) found that during the three years of the study in the Androscoggin River, adults returned to a 1-km reach below the Brunswick Dam and Kieffer and Kynard (1996) found that adults spawned within a 2-km reach in the Connecticut River for three consecutive years. Spawning occurs over channel habitats containing gravel, rubble, or rock-cobble substrates (Dadswell et al. 1984; NOAA Fisheries 1998). Additional environmental conditions associated with spawning activity include decreasing river discharge following the peak spring freshet, water temperatures ranging from 8 - 12° C, and bottom water velocities of 0.4 to 0.7 m/sec (Dadswell et al. 1984; NOAA Fisheries 1998). The eggs are separate when spawned but become adhesive within approximately 20 minutes of fertilization (Dadswell et al. 1984). Between 8° and 12°C, eggs generally hatch after approximately 13 days. The larvae are photonegative, remaining on the bottom for several days. Buckley and Kynard (1981) found week old larvae to be photonegative and form aggregations with other larvae in concealment.

Adult shortnose sturgeon typically leave the spawning grounds soon after spawning. Non-spawning movements include rapid, directed post-spawning movements to downstream feeding areas in spring and localized, wandering movements in summer and winter (Dadswell et al. 1984; Buckley and Kynard 1985; O'Herron et al. 1993). Kieffer and Kynard (1993) reported that post-spawning migrations were correlated with increasing spring water temperature and river discharge. Young-of-the-year shortnose sturgeon are believed to move downstream after hatching (Dovel 1981) but remain within freshwater habitats. Older juveniles tend to move downstream in fall and winter as water temperatures decline and the salt wedge recedes. Juveniles move upstream in spring and feed mostly in freshwater reaches during summer.

Shortnose sturgeon were listed as endangered on March 11, 1967 (32 FR 4001), and they remained on the endangered species list with the enactment of the ESA in 1973. A shortnose sturgeon recovery plan was published in December 1998, to promote the conservation and recovery of the species.

Although shortnose sturgeon are listed as endangered range-wide, in the final recovery plan, NOAA Fisheries recognized 19 separate populations occurring in New Brunswick Canada (1); Maine (2); Massachusetts (1); Connecticut (1); New York (1); New Jersey/Delaware (1); Maryland and Virginia (1); North Carolina (1); South Carolina (4); Georgia (4); and Florida (2). In the plan, NOAA Fisheries stated that loss of a single shortnose sturgeon population segment may risk the permanent loss of unique genetic information that is critical to the survival and recovery of the species and that, therefore, each shortnose sturgeon population should be managed as a Distinct Population Segment (DPS) or recovery unit for the purposes of Section 7 of the ESA.

The Shortnose Sturgeon Recovery Plan (NOAA Fisheries 1998) identifies habitat degradation or loss (resulting, for example, from dams, bridge construction, channel dredging, and pollutant discharges) and mortality (resulting, for example, from impingement on cooling water intake screens, dredging and incidental capture in other fisheries) as principal threats to the species' survival. The recovery goal is identified as delisting shortnose sturgeon populations throughout their range, and the recovery objective is to ensure that a minimum population size is provided such that genetic diversity is maintained and extinction is avoided.

Status of Shortnose Sturgeon in the Potomac River and Chesapeake Bay

The NOAA Fisheries recovery plan (1998) indicates that shortnose sturgeon found in the Chesapeake Bay and its tributaries (including the Potomac River) are considered part of the Chesapeake Bay population. Welsh et al. (1999) summarizes historical and recent evidence of shortnose sturgeon presence in the Chesapeake Bay. The first published account of shortnose sturgeon in the Chesapeake system was an 1876 record from the Potomac River reported in a general list of fishes of Maryland (Uhler and Lugger 1876). Other historical records of shortnose sturgeon in the Chesapeake include: the Potomac River (Smith and Bean 1899), the upper Bay near the mouth of the Susquehanna River in the early 1980's, and the lower Bay near the mouths of the James and Rappahannock rivers in the late 1970's (Dadswell et al. 1984). As indicated previously, the FWS Reward Program for Atlantic Sturgeon began in 1996. Shortnose sturgeon have been incidentally captured via this program as well. As of July, 2002, 50 shortnose sturgeon were captured via the reward program in the Chesapeake Bay and its tributaries – four from the lower Susquehanna River, two in the Bohemia River, six in the Potomac River, two south of the Bay Bridge near Kent Island, one near Howell Point, one just north of Hoopers Island, one in the Elk River and two in Fishing Bay. The remaining shortnose sturgeon were captured in the upper Bay north of Hart-Miller Island. These fish were captured alive in either commercial gillnets, poundnets, fykenets, eel pots, hoop nets, or catfish traps.

The six shortnose sturgeon captured in the Potomac River were documented in the following locations: two at the mouth of the river near Ophelia, Virginia (May 3, 2000 and March 26, 2001); one at the mouth of the Saint Mary's River (April 21, 1998); and three at the mouth of the Potomac Creek (May 17, 1996 and March 8, 2002). The locations of these captures are between 55 and 123 miles downstream from the Washington Aqueduct discharge sites near Little Falls.

Research conducted by the NYU School of Medicine involving mitochondrial DNA (mtDNA) analysis of shortnose sturgeon populations suggests that shortnose sturgeon captured in the upper Chesapeake Bay may have migrated from the Delaware River to the upper Chesapeake through the Chesapeake and Delaware Canal (Grunwald et al. 2002). In this study, genetic comparisons were made among all shortnose sturgeon populations for which tissue samples were available. All population comparisons exhibited clear and significant differences in haplotype frequencies except for comparisons between the Upper/Lower Connecticut River and Delaware/Chesapeake. There were no unique haplotypes in the Chesapeake (Potomac) fish. Samples from four fish from the Potomac River were analyzed and results indicate that these fish exhibited the same haplotypes as fish found elsewhere in the Chesapeake and in the Delaware River. These results suggest that some or all of the sturgeon captured in the Chesapeake Bay and its tributaries may not be part of the Chesapeake DPS, but rather transients from the Delaware population. However, mtDNA represents only a fraction (less than 1%) of the genetic material and is maternally inherited. In order to obtain conclusive results, it is necessary to look at nuclear DNA (nDNA), which represents greater than 99% of the genetic material and is biparentally inherited. The correct genetics standard is to analyze both mtDNA and nDNA in order to make a conclusive statement on the genetic distinctness of a population. In the absence of stronger evidence to the contrary, NOAA Fisheries presumes that shortnose sturgeon captured in the Chesapeake Bay and its tributaries, including the Potomac River, are part of the Chesapeake Bay population.

In addition to implementing the Reward Program for Atlantic sturgeon, the FWS conducted two sampling studies between 1998 and 2000 in the Maryland waters of the Potomac River to determine the occurrence of shortnose and Atlantic sturgeon in areas of proposed ACOE dredge-fill operations. A two-year bottom gillnetting study was conducted at five sites located in the middle Potomac River approximately 30 to 74 miles downstream of the Washington Aqueduct discharge sites. This involved a total of 4,590 fishing hours between the sites. During this study, no shortnose sturgeon were captured. As part of the Potomac River sturgeon sampling study, the FWS also conducted an additional 77 hours of sampling at two other areas in the vicinity of Little Falls, Virginia (the downstream portion of the fall line in the upper tidal Potomac River). This region of the river contains environments that are consistent with the preferred spawning habitat of shortnose sturgeon. The sampling sites were located at the Chain Bridge and the deep hole downstream from the Chain Bridge known as Three Sisters. Anchored gillnets used at Three Sisters consisted of two one hundred foot nets. The anchored gillnets deployed at Chain Bridge consisted of two one hundred foot nets above the bridge and one three hundred foot net below the bridge. Gillnets used at these sites were set in a similar manner as the gillnets used at the sites sampled in the middle Potomac River. The nets at Three Sisters were 3-hour sets and the nets around Chain Bridge were 24-hour sets. No shortnose sturgeon were documented during this study.

These FWS studies may not have been comprehensive enough to determine the presence or absence of sturgeon in the upper tidal Potomac River. A 2000 NOAA Fisheries report, entitled "A Protocol for Use of Shortnose and Atlantic Sturgeons" identified a minimum sampling protocol for use in north central rivers (Chesapeake drainages to the Merrimack River) to confirm shortnose sturgeon presence or absence. The FWS studies did not follow this desired protocol, which was published after the studies commenced. One factor was that the FWS sampling sites may have been too deep in areas with too strong a current to adequately document the presence of shortnose sturgeon. Also, the timing and duration of the sampling events and the type of nets employed may not have been appropriate for targeting shortnose sturgeon in this area. As a result, the lack of sturgeon discovered in the FWS gillnet study should not be used as a conclusive indicator of shortnose sturgeon absence in the upper tidal Potomac River.

In December 2002, NOAA Fisheries provided funding to the FWS to initiate a study to identify the over-wintering habitat, genetic stock composition, and movement of shortnose sturgeon in the Potomac River. The original intent of the project was to use broad-band acoustics to assist in determining possible concentrations of shortnose sturgeon on wintering grounds. As such, ground truthing was performed in mid-December, but unfortunately, it was not possible to gather the appropriate "classifiers" for shortnose sturgeon. In early January, FWS and NOAA Fisheries decided to forego the acoustics and sample areas characteristic of overwintering habitats, similar to those observed in the Delaware River. On January 15, 2003, Jim Cummins (Potomac Interstate Commission) accompanied the FWS to investigate potential sampling areas in the vicinity of Roosevelt Island. In mid-January, the Potomac River experienced severe icing, thereby, prohibiting sampling. The ice began to dissipate in the first week in February, but floating sheets were still present making it impossible to gillnet. On February 14, 2003, the FWS was able to sample for the first time. This sampling was done at Roosevelt Island and consisted of three gillnets which were set for approximately six hours. The following week, the area was again subjected to freezing temperatures, thus freezing the river a second time. FWS made two more unsuccessful attempts to sample on March 4 and 17, 2003. On March 4, 2003, five gillnets were set in the vicinity of Fort Washington, MD for a total of about 7 ½ hours and on March 17, 2003, three gillnets were set near Three Sisters for a total of approximately 4 ½ hours. Due to the snow melt, large amounts of debris and water were flowing in the Potomac, and because of the large quantity of debris, the gillnets were not able to fish properly. Between March 15 and 22, 2003, temperatures rose to 8-10°C. At that temperature, shortnose sturgeon begin to migrate from the overwintering aggregations; therefore, attempts to locate the aggregations at that time would have been unsuccessful and sampling was suspended for the season.

Shortnose sturgeon have not been documented recently in the vicinity of the Aqueduct outfalls. However, in a letter from Mr. Mike Oetker, a trained fishery biologist, to NOAA Fisheries dated October 8, 2002, Mr. Oetker described an incident that occurred in 1999, in which he noted the take of a sturgeon from the Potomac River near Fletcher's Boathouse. Mr. Oetker was not able to discern whether this fish was an Atlantic or shortnose sturgeon but noted that the size was between four and four and one half feet long. A publication from 1898 regarding the fish of the District of Columbia lists shortnose sturgeon as being present in DC waters and Atlantic sturgeon (*Acipenser sturio* later changed to *Acipenser oxyrhynchus oxyrhynchus*) as ascending the Potomac River in the spring to spawn. This publication also explains that fishermen did not typically differentiate between the two species of sturgeon. There is no documentation of shortnose sturgeon spawning anywhere in the Potomac River. However, as mentioned, the FWS study near Little Falls, designed to document spawning, was limited in scope and duration due to adverse river conditions. In addition, shortnose sturgeon are inherently difficult to capture and often there is little evidence of their presence in river systems.

While there is no direct evidence of sturgeon spawning in the Potomac, there is reason to believe that they do so, and that the Little Falls region is likely the preferred spawning location. Six adult sturgeon have recently been captured in downstream reaches of the Potomac River. Shortnose sturgeon appear to spend most of their lives in their natal rivers (NOAA Fisheries 1998). Therefore, sturgeon found in the lower Potomac may reasonably be expected to remain in the Potomac and spawn there. Research on other shortnose sturgeon populations indicates that this species typically spawns just below the limit of upstream passage, often the fall line. In the Potomac River, this upstream limit is likely Little Falls. In addition, research on other shortnose sturgeon populations indicates that shortnose sturgeon prefer to spawn in specific habitats that contain areas with high flow and cobble/gravel substrate. The habitat at and below Little Falls is consistent with this preferred spawning habitat. Therefore, for the purposes of this analysis, NOAA Fisheries has made the precautionary assumption that shortnose sturgeon are present and spawn near Little Falls, and as such, may be affected by the Aqueduct's discharges. This analysis assesses the effects of a discharge from the Aqueduct to the following life stages of shortnose sturgeon: eggs, larvae (young of the year), and adults.

Other tributaries of the Chesapeake Bay that appear to have suitable spawning habitat for

Chesapeake Bay shortnose sturgeon include the Rappahannock, James, York, Susquehanna, Gunpowder and Patuxent Rivers (Pers. Comm. John Nichols, NOAA Fisheries, 2002). A FWS sampling study was also conducted in the upper Chesapeake Bay mainstem, lower Susquehanna River and Chesapeake/Delaware Canal during 1998 and 2000 in conjunction with a Section 7 consultation for the Baltimore Harbor and Channels Federal Navigation Project. This study involved bottom gillnetting at 19 sites within the upper Chesapeake Bay mainstem and lower Susquehanna River, and tracking of sonically tagged sturgeon within the upper Bay and the Canal. No shortnose sturgeon were captured at any of the 19 sites. There have been anecdotal reports made by watermen of shortnose sturgeon presence in Gunpowder Falls, which enters the Gunpowder River in Baltimore County, although there has not been any documentation of spawning activity (Pers. Comm. John Nichols, NOAA Fisheries, 2002). Shortnose sturgeon have been documented by the FWS Reward Program in the Susquehanna River (April 4, 1996; April 24, 1997; April 28, 1998; February 19, 1999; February 6 and 17, 2001; June 2, 2002) and near the mouth of the Rappahannock River (May 1998) (Spells 1998, unpublished report). No spawning activity has been documented in any of these tributaries to the Chesapeake Bay. However, to date, no directed sampling following the NOAA Fisheries Protocols has occurred to determine if a spawning population exists in any of these tributaries. As is the case with the Potomac River, the conservative assumption must therefore be made, that based on the documented presence of this species and suitable spawning habitat in these river systems, and given the life history attributes of shortnose sturgeon, NOAA Fisheries assumes for the purposes of this analysis that shortnose sturgeon from the Chesapeake Bay population are also spawning in at least the Susquehanna, Gunpowder, and Rappahannock River systems.

ENVIRONMENTAL BASELINE

Environmental baselines for biological opinions include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this biological opinion includes the effects of several activities that may affect the survival and recovery of the endangered species in the action area. The activities that shape the environmental baseline in the action area of this consultation generally include the following: water quality impairment, scientific research, fisheries, bridge construction, dredging, and recovery activities associated with reducing the impacts from these activities.

Contaminants and Water Quality
Contaminants including heavy metals, polycyclic aromatic hydrocarbons (PAHs), pesticides, and polychlorinated biphenyls (PCBs), can have serious, deleterious effects on aquatic life and are associated with the production of acute lesions, growth retardation, and reproductive impairment (Ruelle and Keenlyne 1993). Contaminants introduced into the water column or through the food chain, eventually become associated with the benthos where bottom dwelling species like shortnose sturgeon are particularly vulnerable.

Several characteristics of shortnose sturgeon life history including long life span, extended residence in estuarine habitats, and being a benthic omnivore, predispose this species to long term, repeated exposure to environmental contaminants and bioaccumulation of toxicants (Dadswell 1979). In the Connecticut River, coal tar leachate was suspected of impairing sturgeon reproductive success. Kocan (1993) conducted a laboratory study to investigate the survival of sturgeon eggs and larvae exposed to PAHs, a by-product of coal distillation. Only approximately 5% of sturgeon embryos and larvae survived after 18 days of exposure to Connecticut River coal tar (i.e., PAHs) demonstrating that contaminated sediment is toxic to shortnose sturgeon embryos and larvae under laboratory exposure conditions (NOAA Fisheries 1998).

Although there is scant information available on the levels of contaminants in shortnose sturgeon tissues, some research on other related species indicates that concern about the effects of contaminants on the health of sturgeon populations is warranted. Detectable levels of chlordane, DDE (1,1-dichloro-2, 2-bis(p-chlorophenyl)ethylene), DDT (dichlorodiphenyl-trichloroethane), and dieldrin, and elevated levels of PCBs, cadmium, mercury, and selenium were found in pallid sturgeon tissue from the Missouri River (Ruelle and Henry 1994). These compounds were found in high enough levels to suggest they may be causing reproductive failure and/or increased physiological stress (Ruelle and Henry 1994). In addition to compiling data on contaminant levels, Ruelle and Henry (1994) also determined that heavy metals and organochlorine compounds (i.e., PCBs) accumulate in fat tissues. Available data suggest that early life stages of fish are more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976). Although there have not been any studies to assess the impact of contaminants on shortnose sturgeon, elevated levels of environmental contaminants, including chlorinated hydrocarbons, in several other fish species are associated with reproductive impairment (Cameron et al. 1992; Longwell et al. 1992), reduced egg viability (Von Westernhagen et al. 1981; Hansen 1985; Mac and Edsall 1991), and reduced survival of larval fish (Berlin et al. 1981; Giesy et al. 1986). Some researchers have speculated that PCBs may reduce the shortnose sturgeon's resistance to fin rot (Dovel et al. 1992). PCBs may also contribute to a decreased immunity to fin rot. In other fish species, reproductive impairment, reduced egg viability, and reduced survival of larval fish are associated with elevated levels of environmental contaminants including chlorinated hydrocarbons. A strong correlation that has been made between fish weight, fish fork length, and DDE concentration in pallid sturgeon livers indicates that DDE increase proportionally with fish size (NOAA Fisheries 1998).

Point source discharges (i.e., municipal wastewater, paper mill effluent, industrial or power plant cooling water or waste water) and compounds associated with discharges (i.e., metals, dioxins, dissolved solids, phenols, and hydrocarbons) contribute to poor water quality and may also impact the health of sturgeon populations. The compounds associated with discharges can alter the pH of receiving waters, which may lead to mortality, changes in fish behavior, deformations, and reduced egg production and survival. Agriculture and forestry occur within the Potomac River Basin, which potentially results in an increase in the amount of suspended sediment present in the river. Concentrated amounts of suspended solids discharged into a river system may lead to smothering of fish eggs and larvae and may result in a reduction in the amount of available dissolved oxygen.

According to the DC Water and Sewer Authority (WASA)(2000), the majority of point sources (e.g., wastewater treatment plants and industrial discharges) discharging directly to Potomac tidal waters are located in the DC metropolitan area. Due to the high rate of population growth in this area, organic carbon loads from wastewater more than tripled between 1913 and 1944 (WASA 2000). However, better treatment led to a 91% reduction over the next 40 years, and loads are now at pre-1913 levels. Section 305(b) of the CWA requires that states prepare a list biennially of the navigable waterbodies under their jurisdiction. This list describes the water quality in the navigable waterbody and provides an analysis of the extent to which all navigable waters of such State provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife, and allow recreational activities in and on the water. The 2000 *305(b) Potomac River Assessment* divides the DC portion of the Potomac River into three segments: segment 01- Hains Point to the Woodrow Wilson Bridge, segment 02- Key Bridge to Hains Point, and segment 03- Chain Bridge to Key Bridge. The Washington Aqueduct Outfalls 002, 003, and 004 are in the vicinity of segment 03. In the 305(b) assessment, the DC Department of Health (DOH) indicates that the overall use support, which includes waters considered to be safe for humans to swim and from which it is safe to consume fish, in each of the three segments is not supported due to pH, pathogens, and total toxics. The non-attainment sources are considered to be municipal point sources, urban runoff/storm sewer, natural sources, combined sewer overflows (CSO), and other urban runoff. The aquatic life support, however, is fully supported for each of the three segments, which indicates that the dissolved oxygen concentrations, pH, and temperature ranges in each segment are adequate to sustain various aquatic life.

Surveys conducted by DC DOH in segment 03 (an area which encompasses the region immediately below Washington Aqueduct Outfalls 002 through 004), revealed the presence of toxics in the sediment. Fish tissue samples for some species showed elevated levels of contaminants including chlordane and PCBs. Biological samples from selected sites in this segment, suggest that the benthic community is severely stressed, and this stressed condition may be attributed to urban storm water runoff from upstream and polluted streams, CSO events, Aqueduct discharges, and impacts from adjacent industrial facilities.

During the water quality study, EA Engineering, Science and Technology, Inc. performed additional research regarding background levels of TSS in the vicinity of the Aqueduct's outfalls. Records of TSS (measured at Little Falls upstream of the Aqueduct outfalls) covering a period of almost 20 years (1980-1999) indicated that the median suspended load in the Potomac River was 218,000 kg/day. The U.S. Federal Highway Administration indicates in the Biological Assessment for the Woodrow Wilson Bridge Project that the average daily turbidity in the Potomac is 150 NTUs.

Scientific Studies

There have been limited studies targeting the shortnose sturgeon population present in the Potomac River and Chesapeake Bay. The FWS conducted a sampling study sponsored by the ACOE between 1998 and 2000 in the Maryland waters of Chesapeake Bay to determine the occurrence of shortnose and Atlantic sturgeon in areas of proposed dredge-fill operations. This study included fishing at a total of 24 sites within the Bay, five of which were located in the middle Potomac River approximately 30 to 74 miles downstream of the Washington Aqueduct discharge site. During this study, no shortnose sturgeon were captured in the Potomac or Susquehanna rivers. An additional study by the FWS was performed in the Potomac River and included sampling at two areas in the vicinity of Little Falls, Virginia, which are environments that are consistent with the preferred spawning habitat of shortnose sturgeon and are located near the Aqueduct discharge sites. No shortnose sturgeon were captured during this study. In December 2002, NOAA Fisheries provided funding to the FWS to perform a study to identify overwintering aggregations of shortnose sturgeon in the Potomac River. However, due to adverse winter river conditions, this study was limited to approximately 18 hours of sampling effort and did not yield any shortnose sturgeon captures. The FWS Atlantic Sturgeon Reward Program has documented the incidental captures of 50 shortnose sturgeon from various locations in the Bay over the six year duration of the program. The majority of these fish were tagged and tissue samples were taken from 36 fish in order to determine the genetic characteristics of the individuals. As a result of techniques associated with these sampling studies, a limited number of shortnose sturgeon have been subjected to capturing, handling, and tagging.

Fisheries
Historically, the Chesapeake Bay and its tributaries supported a large, very productive commercial fishery for shortnose and Atlantic sturgeon. However, by the early 1900's, overfishing, pollution, and the construction of dams in several of the tributaries to the Bay resulted in a significant decline in both populations. Few shortnose or Atlantic sturgeon were reported as bycatch in Chesapeake Bay fisheries during the mid to late 1900's. Until the Reward Program documented a shortnose sturgeon in 1996 in the Potomac River, it was generally thought that this species had been extirpated from the river. Unauthorized take of shortnose sturgeon is prohibited by the ESA.

The Potomac River is an important corridor for migratory movements of various species of fish including alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), striped bass (*Morone saxatilis*), and white perch (*Morone americana*). As such, shortnose sturgeon have been taken incidentally in other anadromous fisheries in the Potomac River and may be targeted by poachers (NOAA Fisheries 1998). The six shortnose sturgeon reported via the Reward Program were found uninjured in poundnets. It is possible that shortnose sturgeon are subject to additional unreported incidental takes in similar gear types that are set throughout the action area.

Bridge Construction/Demolition
According to the Shortnose Sturgeon Recovery Plan (NOAA Fisheries 1998), bridge construction and demolition projects may interfere with normal shortnose sturgeon migratory movements and

disturb sturgeon concentration areas. As such, the Federal Highway Administration (FHWA) first consulted with NOAA Fisheries on the Woodrow Wilson Bridge Project in the Potomac River in spring, 2000. This ongoing project involves the construction of two new bridge structures crossing the Potomac and the demolition of the existing bridge. The applicants determined that prior to construction, dredging would be necessary to allow barges to navigate safely to the project site and also to provide a channel to access a potential construction staging area. Through an alternatives analysis, it was determined that the most viable option for the demolition of the existing bridge would entail the use of subaqueous explosives. During informal consultation, several measures to minimize the potential impacts to shortnose sturgeon were developed including: time of year restrictions for mechanical dredging (restricted from February 15 through October 15); time of year restrictions for blasting (restricted from February 15 through September 15); the construction of cofferdams to minimize the lethality zone surrounding the blast site; employment of scare charges; and recommendations on the blast design including maximum charge weights, stemming, and delays. In a letter dated February 24, 2000, NOAA Fisheries stated that the determination had been made that provided these conditions were adhered to, the Woodrow Wilson Bridge Project was not likely to adversely affect listed species under NOAA Fisheries jurisdiction.

In August 2001, it was observed that the driving of large diameter steel pipe piles in deep, open water produced shock waves damaging to fish swim bladders, which resulted in unexpected fish kills. The FHWA notified NOAA Fisheries, and it was determined at that time, that because the mortality was intermittent and minimal, the pile driving would be allowed to continue. In April 2002, the mortality increased, and fish mortality threshold recommendations were implemented. The FHWA consulted experts and tested various structures and procedures designed to minimize the effects of the pile driving. Pile driving ceased on July 30, 2002. However, recognizing that additional pile driving was necessary in spring 2003, the FHWA sent a letter to NOAA Fisheries on October 17, 2002 and requested that consultation be reinitiated. FHWA provided NOAA Fisheries with a supplement to the existing biological assessment (BA) on January 13, 2003.

FHWA tested a variety of measures to mitigate the effects of the pile driving. It was determined that the use of sheet pile cofferdams or cans surrounding the area in which the pile is driven in combination with a bubble curtain inside the containment structure (referred to as a contained air bubble curtain system or ABCS), minimizes the pressure waves produced. During the monitoring, it was determined that the use of the ABCS, reduced pressures from 12 to 55 psi inside the cofferdam and six to 17 psi outside the cofferdam to levels well below the established mortality threshold (approximately 1.2 outside and 1.7 inside the cofferdam). NOAA Fisheries determined that the use of the ABCS for the remaining pile driving activities did not change the basis for the original not likely to adversely affect determination conveyed in NOAA Fisheries' February 24, 2000 letter. To date, these measures have proven effective as no shortnose sturgeon have been documented to have been taken by any bridge construction or demolition activities within the action area.

Dredging

Maintenance dredging of federal navigation channels can adversely affect shortnose sturgeon populations. In particular, hydraulic dredges (e.g., hopper and pipeline) have been documented to lethally harm sturgeon by entraining fish in the dredge dragarms and impeller pumps, and mechanical dredges have been documented to take Atlantic sturgeon both in North Carolina and Maine. On April 30, 2003, a shortnose sturgeon was taken by a mechanical bucket dredge during maintenance dredging activities in the Bath Iron Works sinking basin in the Kennebec River, Maine. This take represents the first documented mortality of a shortnose sturgeon in a mechanical bucket dredge.

Dredging in the Potomac River has occurred in the past. The ACOE previously consulted with NOAA Fisheries on this dredging and on July 8, 1999, NOAA Fisheries concluded consultation on the Potomac River dredging finding that the project was not likely to adversely affect listed species under the jurisdiction of NOAA Fisheries. The ACOE completed maintenance dredging of the Potomac River Federal Navigation Channel on February 8, 2000. During this dredging iteration the only portions of the project that were dredged were the Alexandria waterfront, the Hunting Creek Channel, and the Mattawoman Bar. These sites are approximately 16 miles downstream of the Aqueduct outfalls. These areas were dredged to a depth of 24 feet plus one-foot allowable overdepth and a width of 200 feet. Approximately 970,000 cubic yards of material was removed via mechanical dredging and was placed in the Gunston Cove disposal site. No shortnose sturgeon were observed to have been taken as a result of this dredging.

Aggregate Impacts
In summary, shortnose sturgeon and their habitat in the Potomac River may be affected by several different factors including: impaired water quality from both point and non-point sources; incidental take in scientific studies and commercial and recreational fisheries; construction and demolition of bridges; and dredging activities. NOAA Fisheries has collaborated with various federal action agencies conducting work in the Potomac River to minimize the potential for these activities to adversely affect shortnose sturgeon. To date, no adverse impacts to shortnose sturgeon have been documented.

EFFECTS OF THE ACTION

This section of a biological opinion assesses the direct and indirect effects of the proposed action on threatened and endangered species or critical habitat, together with the effects of other activities that are interrelated or interdependent (50 CFR 402.02). Indirect effects are those that are caused later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02).

Summary of the Information Used to Assess the Effects to Shortnose Sturgeon
In order to assess the effects of the action on species indigenous to the Potomac River, EA Engineering, Science and Technology, Inc. was contracted to perform a water quality study on

the area near the three main Aqueduct outfalls. In December 2001, the results of this study were compiled in a final report entitled "Water Quality Studies in the Vicinity of the Washington Aqueduct." A number of questions regarding the validity of these studies and the conclusions drawn in the report arose in response to the issuance of the final report. As a result, at the request of Congressman Radanovich, an independent panel of scientists from the Institute for Regulatory Science (IRS) reviewed the studies and offered comments in a document entitled "Assessment of Water Quality Studies in the Vicinity of the Washington Aqueduct" (the IRS Report 2002). The IRS Report questioned several of the methods used by the consultants and as such, questioned the validity of the results and conclusions, particularly, those pertaining to impacts to shortnose sturgeon.

Due to the questions surrounding the validity of the science used in the 2001 Water Quality Studies report, EPA convened a panel of experts from the EPA Office of Research and Development (ORD) to evaluate the assessment performed by the IRS. The ORD submitted a report entitled "ORD Expert Review of Documents Associated with the 'Water Quality Studies in the Vicinity of the Washington Aqueduct'" on December 17, 2002. The ORD panel recommended that a number of additional studies were needed to ascertain the full effects of the Aqueduct discharges on the aquatic environment. Many of these studies have been incorporated as special conditions into the final NPDES permit for the Washington Aqueduct. In the absence of these data, NOAA Fisheries will use the best available scientific information to assess the effects of this action on shortnose sturgeon. If at the completion of these studies, new information reveals effects of the action that were not analyzed in this consultation, NOAA Fisheries will recommend that consultation be reinitiated.

Additional sediment fate and transport modeling was performed in December 2002 and was a collaborative effort between EPA Region III, EPA ORD and the permittee's contractor. This modeling was done in response to the IRS assessment. The modeling was performed using different assumptions with regard to sediment composition than those in the 2001 Water Quality Studies. The studies showed, among other things, that particle deposition patterns and depths were still very small and not substantially different than the original modeling results; the use of alternative particle size classification reduced the amount of sediment deposition within the area of interest; and the amount of sediment released from the Aqueduct is small relative to naturally occurring sedimentation in the Potomac. This additional modeling resulted in a new report, "Supplemental Modeling Study for the Washington Aqueduct" which was provided to NOAA Fisheries in February 2003.

EPA also performed special sampling on October 21, 2002 in response to comments submitted by the National Wilderness Institute regarding the chemical makeup of the residual solids from the Aqueduct. EPA took samples from the Dalecarlia sedimentation basins during the October 21, 2002 discharge and analyzed the samples at its Fort Meade Laboratory. This work also included the analysis of raw reservoir water, which was used to compare the composition of raw river water versus the aqueous portion of the discharge. Analyses comparing the aqueous portion of the samples (raw reservoir water versus discharge water) showed that the concentrations of arsenic, copper, lead, mercury, selenium and zinc were the same. The analysis showed that the amount of aluminum in the aqueous portion of the discharge is less than that in the raw reservoir water. The aforementioned studies and modeling are the most recent and best available scientific information on the fate and potential constituents of the effluent and as such, will be used in the following analysis of the effects of the action on shortnose sturgeon.

As expected, the concentrations of certain metals were higher in the sediment samples than in the aqueous samples. EPA's "Reasonable Potential Analysis using the results reported by the EPA Region III Office of Analytical Services and Quality Assurance, Fort Meade, MD" is EPA's reasonable potential analysis for aluminum. It demonstrates that, with the exception of total aluminum, the residual solids discharged from the Dalecarlia sedimentation basins do not have the potential to exceed District of Columbia Water Quality Standards. It also computes water quality based effluent limits, which are higher than the technology based limits. Since the technology based limits (4 mg/l average monthly limit, 8 mg/l maximum daily) are tighter than the water quality based limits, EPA has written the stricter technology based limits into the final permit.

EPA also provided NOAA Fisheries with new information on technology based effluent limits. According to EPA (2003), TSS concentrations of 30/60 mg/l have been identified as consistent with best practical control technology for water treatment plants (WTP) discharges, with 30 mg/l "typically" required. A review of more than 400 other permits in EPA Region III showed that other WTP facilities have achieved a TSS limit of 30 mg/l (EPA 2003). In addition, other states such as Michigan use the 30 mg/l monthly average as a treatment-based BPJ limit for WTP backwash discharges.

At least until the ACOE installs a new technology at the Aqueduct, discharges will occur on an intermittent basis as each basin is cleaned. Each basin discharges between two and five times per year. Effluent samples collected during discharges from Outfall 003 in May 2002 (EA 2001) showed that TSS concentrations at Outfall 003 ranged from 4,700 mg/l to 12,300 mg/l and aluminum concentrations ranged from 26 mg/l to 1,300 mg/l.

During the May 2002 sampling, TSS concentrations at Outfall 002, ranged from 4,600 mg/l to 16,500 mg/l and aluminum ranged from 1,020 mg/l to 1,810 mg/l. During EPA sampling on October 21, 2002, TSS levels at Outfall 002 were reported at 4,300 mg/l and aluminum at 983 mg/l. Assuming that the total solids mass and liquid volume reported in the 2001 permit application are released daily rather than only four or five times per year, then the concentration of the releases would average approximately 5,000 mg/l, which is above the 30/60 mg/l permit limit.

Residual handling technologies span a broad range of complexity, ranging from redirecting the residuals to an off-site handling facility to implementing a multiple step, on-site dewatering and disposal process. The process of residuals handling has three parts: (1) the initial handling process that includes on or all of the following - thickening, dewatering and drying; (2) the final disposal of the solids; and (3) the final disposal of the separated liquid, or supernatant.

The ultimate disposal of the solids, and the solids content requirements of that disposal option, drive the selection of the thickening, dewatering and drying processes implemented. The quantity of solids produced and the costs of disposal per unit volume, is also an important part of the decision making process.

According to the provisions of the FFCA, the ACOE will complete an alternatives evaluation and disposal study. The purpose of this study is to identify a range of engineering and /or best management practices capable of achieving the technology-based permit limits.

Effects to Shortnose Sturgeon
In this section, the effects of the action on shortnose sturgeon pertain to the potential impacts from discharges occurring during the time in which the ACOE is operating under the FFCA. As such, the period in which adverse effects to shortnose sturgeon may occur extends from the effective date of the FFCA through the end date of the NPDES permit, March 14, 2008. Once the ACOE achieves compliance with all of the provisions of the NPDES permit issued on March 14, 2003, the effluent limitations that will be in effect will be consistent with the DC Water Quality Standards or EPA's BPJ. At this time, discharges that are in compliance with the numeric effluent limits are not expected to adversely affect any life stages of shortnose sturgeon. NOAA Fisheries, FWS, and EPA are currently engaged in a national section 7 consultation on EPA's water quality standards and aquatic life criteria. These consultations may reveal effects of EPA's program that NOAA Fisheries has not previously considered or they may change national water quality criteria and standards in ways that affect the water quality program in DC. Until such time as a full evaluation of the effects of the water quality standards has been done specifically for shortnose sturgeon, NOAA Fisheries has determined that the existing DC Water Quality Standards are protective of this species. Therefore, only effects from discharges, which occur during the spring spawning season when the ACOE is operating under the FFCA, will be considered.

The direct effects that may result from an Aqueduct discharge, which occurs during the spring spawning season when shortnose sturgeon are expected to be in the vicinity of the outfalls, include adverse impacts from the increase in TSS concentrations, deposition of sediment, and toxic effects of the discharge. Increased TSS concentrations may lead to decreased dissolved oxygen levels, high turbidity, and a reduction in the adhesiveness of fish eggs. Sediment that is deposited on the bottom during a discharge can lead to smothering and entrapment of benthic organisms. Constituents of the discharge such as alum are potentially toxic to fish eggs and larvae. As such, the three potential direct effects on shortnose sturgeon eggs, larvae, and adults are considered in this analysis.

As stated previously, shortnose sturgeon larvae are photonegative, remaining on the bottom for several days. Buckley and Kynard (1981) found week old larvae to be photonegative and form aggregations with other larvae in concealment. Young-of-the-year shortnose sturgeon are believed to move downstream after hatching (Dovel 1981) but remain within freshwater habitats. Adult shortnose sturgeon typically leave the spawning grounds soon after spawning. Kieffer and Kynard (1993) reported that adult shortnose sturgeon post-spawning migrations were correlated with increasing spring water temperature and river discharge. As such, adult shortnose sturgeon are expected to be present in the vicinity of the Aqueduct outfalls and potentially affected by a discharge which occurs between March 1 through April 30 or when temperatures are between 8°C and 15°C. Shortnose sturgeon eggs and larvae are expected to be present from March 15 through May 15.

Because of the velocity and volume of the flow and the scouring effect of storms and snow melt, EPA has indicated that they do not believe that material deposited during a discharge remains in the area for an extended period of time. This supposition is supported by the results of a benthic study performed by Dynamac. In this study, an area upstream of the Washington Aqueduct outfalls was sampled, and researchers were not able to resample locations due to shifting river sediments.

In the Water Quality Studies (EA Engineering, Science and Technology, Inc. 2001), the consultants evaluated the effects of Aqueduct discharges on the benthos utilizing an artificial substrate device called a Hester-Dendy unit. The Hester-Dendy unit allows bottom dwelling organisms to colonize on square plates, and the organisms are then evaluated to characterize the species and numbers of organisms that colonize the units. The sampling protocol for the EA Engineering, Science and Technology, Inc. study used the Hester-Dendy units to allow comparisons between upstream and downstream benthic organism communities and to compare the post-discharge benthic data to the data representing conditions prior to a discharge. The consultants found that the substrate in the region of the Aqueduct outfalls consists of areas of boulders, bedrock, sand and mud. Large bedrock formations are evident at low tide in the region along the shoreline and also in the middle of the river. The softer sediments are found in patches between or on the rocks. The sediments are continually redistributed following medium to high river flow events, which was confirmed by the observations of sediment deposition during the Hester-Dendy study. In this area of the river, there is a very large load of sediment that naturally occurs, moves through during times of increased flows, and is deposited in the wider, slower current velocity segments. This was evident at the downstream stations as well as the upstream reference station. The large amount of naturally occurring sediment found in the area prior to the Georgetown basin discharge event, resulted in the dataset being compromised as so much sediment covered some of the Hester-Dendy units that organisms were not able to colonize the samplers, which resulted in lower than expected numbers of benthic organisms and taxa. The benthic community that was collected consisted of tolerant species, which is a consequence of the rigorous naturally occurring environmental conditions to which they are exposed.

The results of these studies indicate that the sediments in this region are continually redistributed and that there is a high degree of deposition from naturally occurring sediments. It is expected that flushing of accumulated sediments from past discharges will occur as under the final permit, discharges are curtailed approximately one month prior to the time when shortnose sturgeon are expected in the action area for spawning. Therefore, NOAA Fisheries does not anticipate that water treatment residual solids will be present from past discharges when eggs are deposited during the spawning season. Accordingly, the remainder of the consultation will only examine the effects of a discharge during the spring spawning season.

Under the final permit, the Aqueduct is prohibited from discharging from February 15 through June 30. This time period was developed to help ensure the protection of fish species spawning in the Potomac during the spring, including shortnose sturgeon. As indicated, shortnose sturgeon are expected to be in the vicinity of the Aqueduct outfalls only during the spring spawning season (from the beginning of March through mid-May depending on water temperature). The prohibition of sediment release during the spring spawning season is a major departure in permitting for the Aqueduct. In past permits, the Aqueduct was encouraged to release sediments during the high river flows in the spring. The spring is also the time that the ACOE prepares for the peak summer production period by emptying and cleaning the basins to maximize the storage capacity as summer is historically dry in the Mid-Atlantic states. As such, the ACOE has indicated that unexpected conditions could arise during this prohibited time period that would necessitate invoking the bypass provision included in the Aqueduct permit. Under extreme conditions, this provision enables the permitee to discharge during the prohibited time period if there is the potential for loss of life or severe property damage. The bypass is considered a violation of the permit. However, EPA is responsible for determining whether the situation in which the bypass provision was invoked was necessary and if so, EPA has the ability to authorize the violation. The ACOE has stated that this is not expected to occur more than one time during the five-year duration of the permit (Pers. Comm. Tom Jacobus 2002). It is anticipated that a spring discharge will result in effects to shortnose sturgeon eggs, larvae, and adult fish. Therefore, the effects on these life stages from a single Aqueduct discharge over the 5-year life of the permit, which occurs during the spring spawning season, will be analyzed.

Deposition of Sediments

Deposition of solids from a discharge may be more detrimental to benthic organisms than suspended sediment plumes, as the potential exists for smothering, which leads to a decrease in the amount of available dissolved oxygen. Also, large quantities of sediment deposited on the bottom can result in entrapment of benthic organisms.

The modeling results from the Water Quality Studies showed deposition of some sediment in the river following the discharge. The rapid decrease in TSS concentrations downstream from the outfalls is indicative of sediment deposition (EA Engineering, Science and Technology, Inc. 2001). The Water Quality Studies indicate that the majority of the suspended solids fall to the substrate within a relatively short distance of the discharge outfall. Therefore, during a spring discharge, incubating eggs and non-motile larvae within that region may be covered by sediment and may suffer mortality from entrapment within sediments and reduced dissolved oxygen concentrations.

Jenkins et al. (1993) found that 86 percent of juvenile shortnose sturgeon died when exposed to dissolved oxygen concentrations of 2.5 mg/l. Older sturgeon (>100 days) could tolerate dissolved oxygen concentrations of 2.5 mg/l with <20 percent mortality, indicating an increased tolerance for lowered oxygen levels by older fish (NOAA Fisheries 1998).

Studies have been conducted on the effects of sediment deposited on demersal fish eggs. These studies have examined the smothering effect of the sediment and entrapment of larvae beneath the sediment layer. Morgan et al. (1973) found that the deposition of sediments on recently spawned white perch eggs (diameter 0.90 mm), which like shortnose sturgeon eggs are adhesive and demersal, may have more significant effects on eggs than suspended sediment. They determined that blanketing of the eggs by sediment greater than 2 mm in thickness (a covering of 1.2 mm over the top of the egg) resulted in 100 percent mortality; and 50 percent of the eggs died when the sediment thickness was 0.5 to 1.0 mm (Morgan et al. 1973). Researchers also found that the developmental rates of white perch eggs were lowered significantly at a sediment thickness of over 0.8 mm. Bjornn and Reisser concluded that emergence of coho salmon sac fry may be impeded by sediments of 2-6.4 mm in percentages above approximately 10 percent (Bjornn and Reisser 1991 in Waters 1995). Coho salmon eggs are larger than shortnose sturgeon eggs having a diameter of 4.5-6.0 mm and 3.0-3.2 mm, respectively. It is reasonable to expect that sediment deposited in excess of 2 mm will result in a higher degree of shortnose sturgeon egg mortality, as they are smaller than the coho salmon eggs. Because shortnose sturgeon eggs are demersal and adhesive, mortality is expected to result from entrapment of emerging larvae. Also, shortnose sturgeon larvae are photonegative and unable to swim for several days following hatching and therefore, remain on the bottom. Thus, this life stage is also susceptible to smothering by deposited sediments.

Total Suspended Solids

High concentrations of suspended sediments may lead to reduced dissolved oxygen concentrations, which result when organic material in sediment is released into the water column stimulating oxygen consuming bacteria (Burton 1993). As such, suspended sediment may affect fish resources. Sherk et al. (1975) conducted research on the impacts of elevated levels of suspended sediments and found species tolerance ranged from 580 mg/l to 24,500 mg/l. Sherk et al. (1975) also suggested that substantial alterations of striped bass movement as a result of high turbidity were unlikely because striped bass are prolific in estuaries, which are fairly turbid environments (Sherk et al. 1975). Research conducted on other species indicates that certain levels of suspended sediments may be lethal and/or inhibit normal behavior. In extreme cases, exposure to high concentrations has resulted in fish kills due to sediment saturation of the gills (Muncy et al. 1979 in Burton 1993). Surveys on striped bass conducted by Radtke and Turner (1967) found that suspended sediment concentrations as low as 350 mg/l blocked upstream migrations. Vinyard and O'Brien (1976) found reduced activity among largemouth bass and green sunfish exposed to turbidity levels of 14-16 NTUs (Heimstra et al. 1969 in Burton 1993). Wilbur and Clarke (2001) found that short-term pulses (rapid increases within an hour) of suspended sediment concentrations disrupt feeding behavior and the dominance hierarchies in juvenile coho salmon (*Oncorhynchus kisutch*) and also trigger alarm reactions that potentially result in fish relocating downstream from the disturbance. In a laboratory study, rainbow smelt

(*Osmerus mordax*) showed increased swimming behavior which is indicative of an alarm reaction when exposed to suspended sediment concentrations of 10 mg/l or higher (Wilbur and Clarke 2001).

While these results demonstrate that suspended sediment may have an adverse effect on some fish species, observations made during maintenance dredging in the Delaware River indicated that adult sturgeon seem to be able to withstand some degree of suspended sediments given they frequently are found in turbid waters (Hastings 1983). It is unclear at what level suspended sediment begins to affect sturgeon behavior. As discussed, lethal suspended sediment limits on fish in general are difficult to determine because they vary widely among species.

Several studies have examined the effects of suspended solids on fish larvae. Observations in the Delaware River indicated that larval populations may be decimated when suspended material settles out of the water column (Hastings 1983). Larval survival studies conducted by Auld and Schubel (1978) showed that striped bass larvae tolerated 50 mg/l and 100 mg/l suspended sediment concentrations and that survival was significantly reduced at 1000 mg/l. According to Wilber and Clarke (2001), hatching is delayed for striped bass and white perch eggs exposed for one day to sediment concentrations of 800 and 100 mg/l, respectively.

In a study on the effects of suspended sediment on white perch and striped bass eggs and larvae performed by the ACOE (Morgan et al. 1973), researchers found that sediment began to adhere to the eggs when sediment levels of over 1000 parts per million (ppm) were reached. It is likely that sediment and flocculants present in the water from an Aqueduct discharge will detract from the adhesiveness of freshly fertilized shortnose sturgeon spawn (Pers. Comm. John O'Herron, 2002). Affected spawn will therefore, drift with the water currents rather than settling in the crevices of rocks and adhering to the substrate, as would be the case in an undisturbed environment. Drifting spawn are more susceptible to predation.

As stated previously, records of TSS (measured at Little Falls upstream of the Aqueduct outfalls) covering a period of almost 20 years (1980-1999) indicated that the median suspended load in the Potomac River was 218,000 kg/day. The May 25, 2000 discharge event from Dalecarlia Outfall 002 released approximately 17,800 kg of solids. This value is exceeded on 90 percent of the days each year by the daily mass of solids in the Potomac River which pass Little Falls. The May 3, 2000, discharge event from the Georgetown Reservoir released an estimated 153,600 kg of solids. This solids loading from the Georgetown Reservoir is exceeded on 55 to 60 percent of the days each year by the daily mass of solids passing Little Falls.

According to EA Engineering, Science and Technology, Inc. (2001), exposure to TSS levels of 100 mg/l appears to be a conservative threshold for effects on some species. NOAA Fisheries agrees that that TSS levels <100 mg/l are not likely to adversely affect eggs and larvae, at least over short durations. Therefore, we will focus the analysis of TSS effects on areas and times where TSS levels exceed 100 mg/l. Background TSS concentrations in the Potomac River are generally high especially during high flow events and may exceed the 100 mg/l threshold approximately 22 percent of the time on an annual basis (EA Engineering 2001). However, the 100 mg/l threshold is based on the best available scientific information and has been deemed to be the most protective threshold for shortnose sturgeon. Based on the modeled TSS concentrations during discharge events, TSS concentrations in the water column exceeded the 100 mg/l threshold only very near the outfalls.

During the Water Quality Studies and supplemental modeling, plume mapping studies were not conducted at Outfall 004 because it discharges to the same portion of the Potomac River as Outfall 003 and also because Outfall 004 drains a smaller sedimentation basin. Thus, the modeling results for Outfall 003 represent worse case scenarios for this location in the river. In the final permit, there is a requirement that the ACOE slow discharges from Outfalls 003 and 004 to 36 hours. In addition, the ACOE must increase the amount of untreated process water that it uses to flush and clean each of the Georgetown sedimentation basins to twice the amount used for each cleaning in calendar year 2001. During an upset or bypass that occurs during the spring spawning season, the ACOE will use best efforts to slow the rate of discharge from Outfalls 003 and 004 to 72 hours per basin. These measures will increase the dilution of the discharge; thereby, reducing the concentrations of TSS.

In December 2002, a supplemental modeling study was produced by EA Engineering at the request of EPA Region 3 to demonstrate the sensitivity of the predicted sediment transport and deposition scenarios to sediment characteristics (including particle class, shear stress for deposition, and settling velocity). As a result of technical discussions with EPA staff, model scenarios were performed using alternate particle characteristics including:

- a lower depositional shear stress,
- a settling velocity with a concentration dependence,
- a refined model grid.

The results from these studies were presented in EA Engineering's December 2002 Supplemental Modeling report. For both Dalecarlia Outfall 002 and Georgetown Outall 003, model scenarios were performed using the alternate particle characteristics for both the original particle classification, and for an alternate particle classification. The particle classifications used in the original modeling were sand, floc, and silt. The alternate particle classification used only two classifications for sand and a cohesive particle. Resulting plume lengths for water column TSS and sediment deposition are provided in Table 1 (Appendix B). The table includes dimensional results for three scenarios:

1) The original model results provided in EA's October 2002 memo
2) Alternate 1 – Original particle classification with the alternate particle characteristic,
3) Alternate 2 – Alternate particle classification with alternate particle characteristics.

The scenarios examined correspond to flow conditions discussed in the Washington Aqueduct's final permit. These Potomac River flows are 800 mgd for Outfall 002; and 1,500 mgd for Outfall

003. For each model scenario, plume contours for TSS and sediment deposition were evaluated. TSS was examined at a time corresponding to the end of the discharge event, and represents maximum plume build-up before the plume begins to dissipate. It is also important to understand that background TSS concentrations during these events are approximately 6-8 mg/l, and that the values reported are net values above the background concentration. Sediment deposition was examined at the end of the model run, after all water column TSS had either settled or passed beyond the downstream model boundary.

Outfall 002- Dalecarlia

TSS and sediment deposition plume lengths are provided in the top half of Table 1 (Appendix B) for a 3.5-hr discharge event at Outfall 002 under an 800 mgd Potomac River flow condition. Examination of the table indicates that TSS plume lengths for both alternate scenarios are shorter than the original model scenario except for the initial 100 mg/l TSS contour. The downstream sediment deposition plume lengths for the two alternate scenarios were also less than the original model.

Outfall 003- Georgetown

TSS and sediment deposition plume lengths are provided in the bottom half of Table 1 for a 6-hr discharge event at Outfall 003 under a 1,500 mgd Potomac River flow condition. Examination of the table indicates that TSS plume lengths for both alternate scenarios are shorter than the original model scenario for TSS concentrations less than 20 mg/l. At the 100 mg/l and 20 mg/l contours, Alternate-1 had similar plume lengths and Alternate-2 had greater lengths than the original model scenario. The downstream sediment deposition plume lengths for the two alternate scenarios were also less than the original model.

Under most circumstances, juvenile and adult fish and other motile organisms are exposed to localized suspended sediment plumes for short periods (minutes to hours). The relatively short duration of an Aqueduct discharge and the ability of juvenile and adult shortnose sturgeon to relocate downstream from the sediment plume should preclude significant adverse impacts from the effluent on these life stages. However, eggs and larvae present within the impact zone (the zone at which the 100 mg/l TSS threshold is reached) may be adversely affected by the influx of TSS during an Aqueduct discharge. Utilizing the worst case information obtained during both the original modeling and the alternate modeling scenarios, this impact zone encompasses an area approximately 144 m from Outfall 002 and approximately 453 m from Outfalls 003 and 004 and persists throughout the duration of the discharge.

Shortnose sturgeon eggs and larvae are expected to be present in the vicinity of the Aqueduct outfalls during a relatively short time in the spring (from mid March through mid May depending on water temperature). During this time, these life stages would be vulnerable to smothering and entrapment in deposited sediment. Based on the results of scientific studies on the impacts of sediment deposition on other species of fish with demersal eggs, for the purposes of this analysis, NOAA Fisheries anticipates mortality of all shortnose sturgeon eggs and larvae present in the area in which the sediment deposition exceeds 2 mm in thickness.

Toxic effects of the discharge

The discharged sediments (except for the alum, chlorine, and copper sulfate, which may be present in the discharge) are not contaminants or pollutants but rather constituents of the raw river water. There have been no scientific studies indicating that heavy metals such as lead, zinc, selenium, arsenic, mercury, ammonia, and copper are present in high concentrations in the discharge. Based on the lack of information on the presence of these constituents in the discharge, the following analysis relies on the best available scientific information.

Effluent toxicity testing was performed on samples from the Aqueduct in order to determine the toxicity of the discharges to freshwater species. Toxicity tests were conducted on three different components of the Aqueduct effluent: whole effluent samples (for the acute toxicity tests), supernatant from the settled whole effluent (for the chronic toxicity tests), and the settled solids of the whole effluent (for the benthic tests). The water flea (*Daphnia magna*), the fathead minnow (*Pimephales promelas*), and the striped bass (*Morone saxatilis*) were used for the acute toxicity tests. Chronic toxicity tests were performed on the water flea (*Ceriodaphnia dubia*), fathead minnow, and a freshwater algae (*Selenastrum capricornutum*). Test organisms were continuously exposed in the laboratory test for a period of two to ten days (depending on the test) while actual water column exposure in the Potomac, under the conditions specified in the final permit, is expected to be transient, lasting approximately eight hours.

In a study entitled "Assessing contaminant sensitivity of American shad, Atlantic sturgeon, and shortnose sturgeon" (Dwyer et al. 2000), during acute toxicity tests (96-hour Lethal Concentration (LC) 50), researchers found that both species of sturgeon were somewhat more sensitive to contaminant exposure than are rainbow trout. In this study, Atlantic sturgeon were found to be the most sensitive species studied while shortnose sturgeon were the second most sensitive species (Dwyer et al. 2000). In a second assessment, involving 96-hour water renewal toxicity tests, results indicated that the fathead minnow survival test appears to be a reliable estimator of effects to American shad and Atlantic sturgeon. As Atlantic sturgeon appeared to be slightly more sensitive to most contaminants than shortnose sturgeon, and without results to the contrary, the fathead minnow survival test can be a reliable estimator for the effects to shortnose sturgeon as well. It is important to note that during this study, high rates of mortality occurred with the controls and therefore, these results are not conclusive.

While the toxic effects of the Aqueduct discharges on shortnose sturgeon were not assessed, the fathead minnow was used as a test organism, and this species appears to be a reliable estimator of the effects to shortnose sturgeon (Dwyer et al. 2000). Therefore, for the purposes of this analysis and in the absence of direct data to the contrary, NOAA Fisheries considers the results of the toxicity tests for the Aqueduct to be applicable to shortnose sturgeon.

Results indicated that with one exception the whole effluent samples were not acutely toxic to the test organisms. One fathead minnow test showed dose-related toxicity, which resulted in a

96-hour LC50 value of 67.6 percent effluent. The chronic toxicity test results indicated that in two of the four rounds, the effluent was not chronically toxic. In addition, 7-day chronic effluent toxicity tests which were conducted in 1992 by Dynamac showed that the effluent released from the sampled sedimentation basins had no effect on either mortality or growth of the fathead minnows. This result was consistent with observations of fathead minnows living in the sedimentation basins.

The toxicity of aluminum is known to be dependent on pH levels and the presence of other compounds and may vary depending upon environmental conditions and the presence of the dissolved form of the metals (Sutherland 1999). Sutherland (1999) reports that studies with juvenile striped bass have indicated that this species is very sensitive to several forms of aqueous aluminum. Studies indicate that aluminum toxicity varies depending on the surrounding environmental conditions. Polymers created from aluminum and water collect on gills thereby limiting respiration (Sutherland 1999). Changes in the polymerization process occur when waters with different pH, temperature, and ionic strength are mixed or when wastewater is discharged into a river system (Sutherland 1999).

The dissolved form of aluminum is believed to be more toxic than the total form of aluminum. Toxicity test results demonstrate that total aluminum concentrations for the Dalecarlia and Georgetown basins averaged 2,273 and 1,510 mg/l respectively, for the period from 1997 - 2001. EPA's October 21, 2002, sampling found total aluminum at 983,000 ug/L (983 mg/l). The EPA 1988 aluminum criteria document lists LC50 concentrations for several fish species ranging from 3,600 to 50,000 ug/L. However, during a typical 3.5 hour discharge event, these concentrations will exist in a small area for a very short period of time. Further, LC50 values for fish are based on a 96 hour continuous exposure to a given concentration in a laboratory, whereas exposure to elevated concentrations in the river during a discharge event are expected to last for a short period of time, (four to twelve hours (and longer according to the terms of the FFCA) depending upon the size of the basin being discharged). The laboratory experiment values are derived from dissolved aluminum whereas the aluminum in the discharge is the less toxic form measured as total aluminum.

Benthic testing on the settled solids of the whole effluent was also conducted. Growth effects were seen in the benthic organisms, and without evidence to the contrary, similar results are expected to occur to shortnose sturgeon eggs and larvae buried under sediments discharged from the Aqueduct. In toxicological studies on the sediments in the Anacostia River, which is generally believed to be a contaminated system, results indicate that there is a reduction in the growth of the benthic organisms tested (Pers. Comm. Beth McGee, FWS, 2002). As such, because the benthic testing utilizing samples from the Aqueduct showed an adverse response similar to that which resulted from the experiments conducted on the sediments from the Anacostia River (i.e., a reduction in growth), adverse effects to shortnose sturgeon eggs and larvae are reasonably certain to occur as a result of burial under sediments discharged from the Aqueduct (Pers. Comm. Beth McGee, FWS, 2002).

On October 21, 2002, the ACOE discharged solids from Dalecarlia sedimentation basin number two. EPA sampled the supernatant and solids from that basin as well as aqueous samples from the Dalecarlia Reservoir. The samples were analyzed at EPA's laboratory at Fort Meade for the following parameters: volatile organics, pesticides/PCBs, herbicides, BOD, TSS, chloride, nitrite, sulfate, fecal coliform, dissolved and total metals, and total residual chlorine.

EPA performed a reasonable potential analysis using the results of the October 21 sampling. The reasonable potential analysis showed that the effluent and stream samples for dissolved arsenic, dissolved nickel, dissolved copper and dissolved zinc were below quantitation limits. EPA, therefore, assumed that the concentration for these parameters is zero and no reasonable potential analysis was necessary for these metals.

A reasonable potential analysis performed on total aluminum results analyzed from the October 21, 2002 sampling found that total aluminum had the potential to exceed water quality standards. Therefore, EPA calculated water quality based effluent limits for total aluminum. EPA calculated limits of 41.9 mg/l average monthly and 61.2 mg/l maximum daily averages. Since the District of Columbia does not have a water quality standard for total aluminum, EPA used the technology-based limits of 4 mg/l monthly average and 8 mg/l daily maximum aluminum for the draft permit. In this case, the technology-based limits are more restrictive than the calculated water quality-based limits and the stricter limits apply.

EPA has indicated that the dissolved form of metals is most appropriate in accurately determining risk to aquatic organisms. The Water Quality Studies indicate that in the project area the dissolved aluminum concentrations were approximately 15 percent of the total concentrations, and therefore, it is unlikely that toxic effects would be present beyond the immediate vicinity of Outfall 002 or beyond 300-400 m below Outfalls 003 and 004. Although total aluminum concentrations from the Aqueduct discharges are high, effluent toxicity testing indicates that the aluminum in the effluent samples is not highly bioavailable or toxic (EA Engineering, Science and Technology, Inc. 2001). EPA has indicated that from the results of the water quality studies, it is anticipated that aluminum concentrations in the river will return to ambient or background levels within approximately 3.5 hours of the discharge event. Therefore, toxic effects to shortnose sturgeon from the alum in the discharge are not expected beyond the immediate vicinity of Outfall 002 or 400 m below Outfalls 003 and 004.

In summary, while whole effluent from Aqueduct discharges have not been demonstrated to have toxic effects to test organisms, there is the potential for toxic effects to any adult shortnose sturgeon that may be in the immediate vicinity of Outfall 002 or within 400 m below Outfalls 003 and 004 as a result of high levels of dissolved aluminum in these areas. However, these increased levels of dissolved aluminum are not expected to be long lasting and it is not reasonably certain that the dissolved aluminum will have toxic effects on adult shortnose sturgeon. In addition, adverse affects to shortnose sturgeon eggs and larvae are reasonably certain to occur as a result of burial under sediments discharged from the Aqueduct.

Disruption of spawning behavior and migratory movements
Seasonal floods and changes in temperature, velocity, and turbidity may all be cues in triggering spawning in shortnose sturgeon. As such, the suspended sediment plumes, changes in ambient river temperature, and alterations in the flow rates resulting from an Aqueduct discharge could interfere with adult shortnose sturgeon migratory movements and spawning behavior. Shortnose sturgeon typically spawn when water temperatures are between 8- 12°C. However, Kynard (1997) found that in 1994, when high river flows delayed spawning, shortnose sturgeon had the physiological flexibility to spawn successfully at 18°C. Therefore, disruptions in shortnose sturgeon spawning behavior directly related to changes in the ambient river temperature and velocities are expected to be limited. As indicated previously, the short-term pulses in turbidity triggered alarm reactions in both coho salmon and rainbow smelt and, therefore, the rapid change in turbidity associated with the sediment plume could result in fish abandoning a spawning run and returning to downstream reaches of the river (Wilber and Clarke 2001). However, concentrations of adult shortnose sturgeon migrating to the spawning grounds would be expected to be present in the action area during the limited spring spawning season only (e.g., from the beginning of March through mid-May depending on water temperature) when Aqueduct discharges are normally prohibited. If the ACOE determines that it is necessary to invoke the bypass provision of the permit and discharge sediments during this time, the effects of the discharge on the migratory movements and spawning behavior of adult shortnose sturgeon in the Potomac River will be limited since only one such discharge for the entire Aqueduct operation in the five-year duration of the NPDES permit is anticipated.

Aggregate effects of the discharges
The Dalecarlia (Outfall 002) and Georgetown (Outfalls 003 and 004) basins are located approximately three miles apart. It is common practice for the ACOE to schedule basin cleanings one week apart, although there have been infrequent occasions when due to river levels, it was necessary to have consecutive cleanings (i.e., two basins within 48 hours). The principle factor in determining when individual basins are to be cleaned is the amount of solid volume accumulation in each basin. As storage volume is a factor in the production of safe drinking water, it is the ACOE's practice to never have more than two basins simultaneously out of service. Because of the velocity and volume of the flow and the scouring effect of storms and snow melt, EPA has indicated that they do not believe that material deposited during a discharge remains in the area for an extended period of time. This supposition is supported by the results of a benthic study performed by Dynamac. In this study, an area upstream of the Washington Aqueduct outfalls was sampled, and researchers were not able to resample locations due to shifting river sediments. Also, the Hester-Dendy study performed by EA Engineering, Science and Technology, Inc. documented the presence of a very high naturally occurring sediment load in the Potomac River near the Aqueduct outfalls. The consultants found that the sediments in this region of the river are continually redistributed following medium to high river flow events. The benthic community that was collected during the course of the Hester-Dendy study consisted of tolerant species, which is a consequence of the rigorous naturally occurring environmental conditions to which they are exposed. NOAA Fisheries concurs with EPA's assessment that the

material deposited during a discharge does not remain in the area for an extended period of time. Also, due to the fact that this BO considers the effects of a single discharge from the entire Aqueduct facility during the spring spawning season, aggregate effects of multiple discharges on shortnose sturgeon have not been analyzed.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur within the action area considered in the biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA.

Specific impacts to shortnose sturgeon from non-federal activities are largely unknown in this river. Occasional incidental takes of shortnose sturgeon occur throughout Chesapeake Bay and some of the tributaries during recreational and commercial fishing for anadromous fish species. Pollution from point and non-point sources has been a significant problem in this river system, which continues to be impacted by discharges from sewer treatment facilities, run off from agricultural operations, and erosion of the streambank. These activities may affect shortnose sturgeon in the Potomac River in the future.

INTEGRATION AND SYNTHESIS OF EFFECTS

Shortnose sturgeon are endangered throughout their entire range. This species exists as 19 separate populations that should be managed as such; specifically, the extinction of a single shortnose sturgeon population risks permanent loss of unique genetic information that is critical to the survival and recovery of the species. The shortnose sturgeon residing in the Chesapeake Bay and its tributaries form one of the 19 populations.

Adult shortnose sturgeon are known to be present in the Potomac River, as documented by the six captures via the FWS Atlantic Sturgeon Reward Program. However, the presence of all life stages within the action area itself has not been documented. However, based on the life history and migratory movements of shortnose sturgeon in other river systems and the presence of suitable shortnose sturgeon spawning habitat near Little Falls, NOAA Fisheries believes that shortnose sturgeon are spawning in the Potomac River near Little Falls. Based on information on the distribution of juvenile shortnose sturgeon in other river systems, juvenile fish are not expected in the vicinity of the Aqueduct outfalls and are not likely to be adversely affected by this action. Therefore, the effects to the following life stages of shortnose sturgeon have been assessed: eggs, larvae (young of the year), and adults.

Available data indicate that discharges from the Aqueduct generally are not acutely or chronically toxic to adult fish. None of the toxicity tests were performed on shortnose sturgeon, but they were performed on another species of fish, which has been determined to be a reliable estimator for the effects to shortnose sturgeon. The results of the laboratory tests conducted are conservative as the test organisms were continuously exposed for a period between two and 10 days. The actual water column exposure in the Potomac is transient. Also, based on the results of scientific research assessing the sensitivity of shortnose sturgeon and Atlantic sturgeon to contaminants, it is assumed that the fathead minnow survival test is a reliable estimator for the effects on shortnose sturgeon. As such, it has been concluded that the results derived from these tests are sensitive enough to be used in assessing the toxic effects of the effluent on shortnose sturgeon.

While a discharge from the Aqueduct is not likely to result in direct adverse affects to adult shortnose sturgeon, NOAA Fisheries contends that shortnose sturgeon eggs and larvae present in the vicinity of an Aqueduct discharge, are likely to be adversely affected by the discharge. A discharge that occurs when eggs and/or larvae are present will likely result in direct injury and/or mortality of fish through entrapment under sediments, decreased dissolved oxygen concentrations, and adverse effects from the effluent. However, these effects are limited to the eggs and larvae that are present in the vicinity of the discharge, which is expected to be from mid-March through mid-May. Indirect effects of a discharge on Chesapeake Bay shortnose sturgeon include the disruption of migratory movements and impaired recruitment, as the rapid change in turbidity associated with the sediment plume could result in adult shortnose sturgeon abandoning a spawning run and returning to downstream reaches of the river. While this could result in harassment of adult shortnose sturgeon, which is considered a take under the ESA, it is not anticipated as the timing of the one bypass discharge would have to be directly correlated with the limited duration of the spawning run. Environmental conditions suitable for shortnose sturgeon spawning may be available for only three to six days (Taubert 1980b; Buckley and Kynard 1985). Also, the plume that contains high TSS concentrations does not cover the entire river; thereby, leaving room for shortnose sturgeon to potentially avoid the disturbance. As such, it is the opinion of NOAA Fisheries that the indirect effect of the Aqueduct discharge on the spawning migration of shortnose sturgeon is unlikely and, therefore, will not result in adverse effects to adult shortnose sturgeon.

As indicated previously, under the final permit, the Aqueduct is prohibited from discharging from February 15 through June 30. The prohibition of sediment release during the spring spawning season is a major departure in permitting for the Aqueduct. In past permits, the Aqueduct was encouraged to release sediments during the high river flows in the spring. The spring is also the time that the ACOE prepares for the peak summer production period by emptying and cleaning the basins to maximize the storage capacity as summer is historically dry in the Mid-Atlantic states. As such, the ACOE has indicated that unexpected conditions could arise during this prohibited time period that would necessitate invoking the bypass provision included in the Aqueduct permit. This provision enables the permitee to discharge during the prohibited time period if there is the potential for loss of life or severe property damage. The bypass is considered a violation of the permit. However, EPA is responsible for determining whether the situation in which the bypass provision was invoked was necessary and if so, EPA has the ability to authorize the violation. The ACOE has stated that this is not expected to occur more than one time during the five-year duration of the permit (Pers. Comm. Tom Jacobus

2002). Given the fact that female shortnose sturgeon spawn once every three years, a discharge would affect the eggs of only 33 percent of the spawning age females, on average, in any given year. Those eggs would represent no more than 20 percent of the eggs spawned in a five-year permit cycle, on average. However, because shortnose sturgeon eggs and larvae are dispersed within the river (generally within a one to two km reach), only those eggs and larvae present within the zone of impact surrounding the outfalls (e.g., the area affected by the deposition of sediments, toxicity, and TSS) will suffer effects. Therefore, the eggs expected to suffer effects from a discharge would likely be less than 100 percent of the eggs deposited that particular year and less than 20 percent of all eggs spawned in the five year permit cycle.

Based on the seasonal distribution and migratory nature of shortnose sturgeon, the permit condition that prohibits discharges from February 15 through June 30 (which encompasses the spring spawning season for shortnose sturgeon), the acute and chronic toxicity test results, and the sediment plume mapping results, NOAA Fisheries has determined that the incidental take associated with an Aqueduct discharge will be limited to eggs and larvae present in the vicinity of the outfalls. Considering the environmental baseline, the effects of the proposed action, and future cumulative effects in the action area, the issuance of the NPDES permit and FFCA is not likely to reduce the reproduction, numbers, and distribution of the Chesapeake Bay population in a way that appreciably reduces their likelihood of survival and recovery in the wild and therefore, is not likely to reduce the reproduction, numbers, and distribution of the species as a whole in a way that appreciably reduces the likelihood of survival and reproduction in the wild. This determination is based on the following: (1) shortnose sturgeon are most likely spawning in other tributaries to the Chesapeake Bay (such as the Susquehanna, Gunpowder, and Rappahannock rivers); (2) discharges are prohibited during the spring spawning season and may only happen under the standard bypass provision in the permit; (3) the bypass is considered a violation of the permit and therefore, will only occur under extreme circumstances; (4) the likelihood of a bypass discharge occurring when eggs and/or larvae are present (March through mid May) is low; (5) individual female shortnose sturgeon most likely spawn at a maximum of every three years, and therefore, a discharge is expected to 33 percent of the spawning age females, on average, in any given year; (6) the eggs affected during a discharge would represent no more than 20 percent of the eggs spawned in a five-year permit cycle, on average; and (7) eggs and larvae are dispersed within the river (generally within a one to two km reach) and not all areas of the river are affected by the discharge.

CONCLUSION

After reviewing the current status of the species discussed herein, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is NOAA Fisheries' biological opinion that a single spring discharge which occurs during the time in which the Washington Aqueduct is operating under the FFCA may adversely affect shortnose sturgeon eggs and larvae but is not likely to jeopardize the continued existence of Chesapeake Bay shortnose sturgeon or the species as a whole. NOAA Fisheries has also concluded that the single spring discharge is not likely to adversely affect juvenile or adult shortnose sturgeon present in the vicinity of the Aqueduct discharge outfalls. No critical habitat has been designated for this species, and therefore, none will be affected.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NOAA Fisheries to include any act, which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering. Harass is defined by FWS as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the EPA so that they become binding conditions for the exemption in Section 7(o)(2) to apply. The EPA has a continuing duty to regulate the activity covered by this Incidental Take Statement. If the EPA (1) fails to assume and implement the terms and conditions or (2) fails to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms, the protective coverage of Section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the EPA must report the progress of the action and its impact on the species to the NOAA Fisheries as specified in this Incidental Take Statement [50 CFR §402.14(I)(3)].

According to the FFCA, the ACOE must achieve full compliance with the numeric effluent limits specified in the NPDES permit within approximately six and one half years (by December 30, 2009). The duration of the permit is five years from its implementation. Because the compliance schedule specified in the FFCA exceeds the duration of the permit and initiation of section 7 consultation will be necessary when a new permit is issued, this incidental take statement is valid for the five year duration of the permit only.

Extent of Take Anticipated
Based on the evaluation of current information on shortnose sturgeon use of the Potomac River, NOAA Fisheries has concluded that a Washington Aqueduct discharge occurring in the spring during the time in which the permit and the FFCA are in effect is likely to result in smothering and adverse effects to shortnose sturgeon eggs and larvae present in the vicinity of the Aqueduct outfalls. However, discharges during the spring spawning season when eggs and larvae would be

expected to be present in the area are prohibited from February 15 to June 30, except under the standard bypass provisions provided in the permit. In order to ensure safe drinking water for its constituents, the ACOE has indicated that the potential exists that it could be necessary to invoke the bypass provision during the spring spawning season. NOAA Fisheries anticipates that in the event that the bypass provision is invoked one time (for the Aqueduct facility as a whole) during the time in which the Washington Aqueduct is operating under the permit and FFCA and a discharge occurs during the prohibited time period either between March 1 and May 15 or when Potomac River water temperatures near Little Falls exceed 8°C (when shortnose sturgeon are expected to be present), it will result in the incidental take through injury and/or mortality of all shortnose sturgeon eggs and larvae present within 144 m of Outfall 002 and 453 m of Outfalls 003 and 004. This incidental take is based on the locations of the 100 mg/l TSS contour (the TSS threshold), the area in which toxic effects from dissolved aluminum would be present, and the depositional footprint of the sediment plume. The impact zone for Outfall 002 is less than the area for Outfalls 003 and 004 due to the high river velocities found at Outfall 002, which disperse the sediments at a quicker rate.

Effect of Take
In the accompanying biological opinion, NOAA Fisheries determined that this level of anticipated take is not likely to result in jeopardy to the species. This level of anticipated take is supported by the following: (1) the contention that shortnose sturgeon are most likely spawning in other tributaries to the Chesapeake Bay (such as the Susquehanna, Gunpowder, and Rappahannock rivers); (2) discharges are prohibited during the spring spawning season and may only happen under the standard bypass provision in the permit; (3) the bypass is considered a violation of the permit and therefore, will only occur under extreme circumstances; (4) the likelihood of a bypass discharge occurring when eggs and/or larvae are present (March through mid May) is low; (5) individual female shortnose sturgeon most likely spawn at a maximum of every three years, and therefore, a discharge is expected to 33 percent of the spawning age females, on average, in any given year; (6) the eggs affected during a discharge would represent no more than 20 percent of the eggs spawned in a five-year permit cycle, on average; and (7) eggs and larvae are dispersed within the river (generally within a one to two km reach) and not all areas of the river are affected by the discharge.

Reasonable and prudent measures
The following reasonable and prudent measures are necessary and appropriate to minimize the impacts of the incidental take of endangered shortnose sturgeon.

1. In order to monitor the level of incidental take, ichthyoplankton sampling must be done immediately before, during, and after a spring discharge, which occurs between March 1 through May 15 or when water temperatures are between 8°C and 15°C.

2. Surface, mid-depth, and bottom water temperatures must be recorded 24 hours prior to a discharge occurring during the prohibited spring spawning season (March 1 through May 15).

Terms and conditions
In order to be exempt from the prohibitions of section 9 of the ESA, the EPA must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline the required reporting requirements. These terms and conditions are non-discretionary.

1. Within two months of the issuance of this BO, EPA and the ACOE must coordinate with NOAA Fisheries to develop an ichthyoplankton sampling protocol to determine the magnitude and nature of the effects of an Aqueduct discharge on shortnose sturgeon eggs and/or larvae. The sampling protocol must be employed immediately before, during, and after a discharge that occurs from March 1 through May 15 or when water temperatures are between 8°C and 15°C. This sampling will most likely consist of placing plankton nets (1.0 mm mesh in water with very low debris load and 2.0 mm mesh in water with a high debris load) within and beyond the depositional zone of the sediment plume. Should the ichthyoplankton sampling document the take of shortnose sturgeon, EPA and/or the ACOE must immediately contact the Endangered Species Coordinator, NOAA Fisheries Northeast Region Protected Resources Division at (978) 281-9328.

2. Between March 1 and May 15, 24 hours in advance of a bypass discharge or within 24 hours of the commencement of the discharge, the EPA and/or the ACOE must provide NOAA Fisheries with information on the water temperatures in the vicinity of the outfall at which the discharge will occur. Prior to the discharge taking place or within 24 hours of the commencement of the discharge, this information should be faxed to the Endangered Species Coordinator, Protected Resources Division, at 978-281-9394.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. NOAA Fisheries has determined that, provided a discharge during the spring spawning season does not occur more than one time within the five year duration of the permit, the issuance of a NPDES permit for the Washington Aqueduct is not likely to jeopardize the continued existence of endangered shortnose sturgeon located in the vicinity of the project area. To further reduce the adverse effects to listed species, NOAA Fisheries recommends that ACOE implement the following conservation recommendations.

1. Population information on all life stages is still sparse for this river system and the Chesapeake Bay. EPA and the ACOE should support further studies to evaluate habitat and the use of the river and the Bay, in general, by shortnose sturgeon.

REINITIATION OF CONSULTATION

This concludes formal consultation on the EPA's issuance of the NPDES permit and FFCA for the Washington Aqueduct. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may not have been previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species; or (4) a new species is listed or critical habitat designated that may be affected by the identified action. In instances where the amount or extent of incidental take is exceeded, Section 7 consultation must be reinitiated immediately. Please note that should it be necessary to invoke the bypass provision more than one time within the five year duration of the permit, consultation must be reinitiated as at that point, the effects of this modified action to the long-term viability of the Chesapeake Bay shortnose sturgeon DPS must be considered. Depending on the circumstances necessitating the discharge, this situation may potentially result in an emergency consultation being conducted.

LITERATURE CITED

Auld, A.H., and J.R. Schubel. 1978. Effects of suspended sediment on fish eggs and larvae: A laboratory assessment. Estuarine and Coastal Marine Science 6: 153-164.

Beamesderfer, Raymond C.P. and Ruth A. Farr. 1997. Alternatives for the protection and restoration of sturgeons and their habitat. Environmental Biology of Fishes 48: 407-417.

Berlin, W.H., R.J. Hesselberg, and M.J. Mac. 1981. Chlorinated hydrocarbons as a factor in the reproduction and survival of lake trout (Salvelinus namaycush) in Lake Michigan. Technical Paper 105 of the U.S. Fish and Wildlife Service, 42 pages.

Buckley, J. and B. Kynard. 1985. Habitat use and behavior of pre-spawing and spawning shortnose sturgeon, *Acipenser brevirostrum*, in the Connecticut River. North American Sturgeons: 111-117.

Burton, W.H. 1993. Effects of bucket dredging on water quality in the Delaware River and the potential for effects on fisheries resources. Versar, Inc., 9200 Rumsey Road, Columbia, Maryland 21045.

Cameron, P., J. Berg, V. Dethlefsen and H. von Westernagen. 1992. Developmental defects in pelagic embryos of several flatfish species in the southern North Sea. Netherlands Journal of Sea Research. 29(1-3): 239-256.

Camp Dresser & McKee Inc. Environmental Engineers. 1979. Report on Site Disposal

Study for Water Treatment Plant Waste Residues Dalecarlia Water Treatment Plant and Georgetown Reservoir. Prepared for the Washington Aqueduct Division. U.S. Army Corps of Engineers. Baltimore District.

Dadswell, M.J., B.D. Taubert, T.S. Squiers, D. Marchette, and J. Buckley. 1984. Synopsis of biological data on shortnose sturgeon, *Acipenser brevirostrum* Lesueur 1818. NOAA Technical Report, NOAA Fisheries 14, National Marine Fisheries Service. October 1984 45 pp.

Dovel, W.L., A.W. Pekovitch, and T.J. Berggren. 1992. Biology of the shortnose sturgeon (*Acipenser brevirostrum* Lesueur 1818) in the Hudson River estuary, New York. Pages 187-216 in C.L. Smith (editor). Estuarine research in the 1980s. State University of New York Press, Albany, New York.

Dwyer, F. James, Douglas K. Hardesty, Christopher G. Ingersoll, James L. Kunz, and David W. Whites. 2000. Assessing contaminant sensitivity of American shad, Atlantic sturgeon, and shortnose sturgeon. Final Report. U.S. Geological Survey. Columbia Environmental Research Center, 4200 New Have Road, Columbia, Missouri.

Dynamac Corporation. 1992. Impacts of sedimentation basin discharges from the Dalecarlia and Georgetown Reservoirs on the Potomac River: Final Report. Prepared for Planning Division. U.S. Army Corps of Engineers Baltimore District.

EA Engineering, Science, and Technology, Inc. 2001. Water Quality Studies in the Vicinity of the Washington Aqueduct. Prepared for the U.S. Army Corps of Engineers, 5900 MacArthur Boulevard, N.W., Washington, D.C. 20315.

Engineering Program Management Consultant- III. 2001. Combined Sewer System Long Term Control Plan. Section 6: Pollutant Loads and Predicted Water Quality. Prepared for District of Columbia Water and Sewer Authority. Pages 6.1-6.9.

Environmental Protection Agency. 2003. Biological evaluation for the issuance of permit DC0000019 Washington Aqueduct. EPA Region III, Philadelphia, Pennsylvania.

Environmental Protection Agency - Office of Research and Development. 2002. ORD Expert Review of Documents Associated with the "Water Quality Studies in the Vicinity of the Washington Aqueduct." Submitted by Ronald B. Landy, US EPA.

Eyler, Sheila M., Jorgen E. Skjeveland, Michael F. Mangold, and Stuart A. Welsh. 2000. Distribution of Sturgeons in Candidate Open Water Dredged Material Placement Sites in the Potomac River (1998-2000). U.S. Fish and Wildlife Service, Annapolis, MD. 26 pp.

Giesy, J.P., J. Newsted, and D.L. Garling. 1986. Relationships between chlorinated hydrocarbon concentrations and rearing mortality of chinook salmon (Oncorhynchus tshawytscha) eggs from Lake Michigan. Journal of Great Lakes Research 12(1):82-98.

Government of District of Columbia. 2000. DC 305(b) Report. Prepared by Department of Health Environmental Health Administration- Bureau of Environmental Quality. Washington, D.C.

Grunwald, C., J. Stabile, J.R. Waldman, R. Gross, and I. Wirgin. 2002. Population genetics of shortnose *sturgeon (Acipenser brevirostrum)* based on mitochondrial DNA control region sequences. Molecular Ecology 11: 000-000.

Hansen, P.D. 1985. Chlorinated hydrocarbons and hatching success in Baltic herring spring spawners. Marine Environmental Research 15:59-76.

Hastings, R.W. 1983. A study of the shortnose sturgeon (*Acipenser brevirostrum*) population in the upper tidal Delaware River: Assessment of impacts of maintenance dredging. Final Report to the U.S. Army Corps of Engineers, Philadelphia, Pennsylvania. 129 pp.

Heimstra, N.W., D.K. Damkot, and N.G. Benson. 1969. Some effects of silt turbidity on behavior of juvenile largemouth bass and green sunfish. Bur. Sport Fish. Wildl. Tech Paper 20:3-9. In: Burton, W.H. 1993. Effects of bucket dredging on water quality in the Delaware River and the potential for effects on fisheries resources. Versar, Inc., 9200 Rumsey Road, Columbia, Maryland 21045.

Institute for Regulatory Science. 2002. Assessment of Water Quality Studies in the Vicinity of the Washington Aqueduct. Columbia, Maryland. 134 pp.

Jenkins, W.E., T.I.J. Smith, L.D. Heyward, and D.M. Knott. 1993. Tolerance of shortnose sturgeon, *Acipenser brevirostrum*, juveniles to different salinity and dissolved oxygen concentrations. Proceedings of the Southeast Association of Fish and Wildlife Agencies, Atlanta, Georgia.

Kieffer, M.C. and B. Kynard. 1993. Annual movements of shortnose and Atlantic sturgeons in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 1221: 1088-1103.

Kocan, R.M., M.B. Matta, and S. Salazar. 1993. A laboratory evaluation of Connecticut River coal tar toxicity to shortnose sturgeon (*Acipenser brevirostrum)* embryos and larvae. Final Report to the National Oceanic and Atmospheric Administration,

NMFS SUPP. 2431

Seattle, Washington.

Longwell, A.C., S. Chang, A. Hebert, J. Hughes and D. Perry. 1992. Pollution and developmental abnormalities of Atlantic fishes. Environmental Biology of Fishes 35:1-21.

Mac, M.J., and C.C. Edsall. 1991. Environmental contaminants and the reproductive success of lake trout in the Great Lakes: An epidemiological approach. Journal of Toxicology and Environmental Health 33:375-394.

Morgan, R.P., V.J. Rasin and L.A. Noe. 1973. Effects of Suspended Sediments on the Development of Eggs and Larvae of Striped Bass and White Perch. Natural resources Institute, Chesapeake Biological Laboratory, U of Maryland, Center for Environmental and Estuarine Studies. 20 pp.

National Marine Fisheries Service. 1998. Recovery plan for the shortnose sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland 104 pp.

NOAA Fisheries, 1996b. Status Review of shortnose sturgeon in the Androscoggin and Kennebec Rivers. Northeast Regional Office, National Marine Fisheries Service, unpublished report. 26 pp.

O'Herron, J.C., K.W. Able, and R.W. Hastings. 1993. Movements of shortnose sturgeon (*Acipenser brevirostrum)* in the Delaware River. Estuaries 16:235-240.

Potomac Crosing Consultants. 2000. Shortnose Sturgeon Biological Assessment – Woodrow Wilson Bridge Project. Prepared for U.S. Federal Highway Administration, The Rotunda – Suite 200, 711 West 40th Street, Baltimore, MD.

Radanovich, George. July 11, 2003. Personal website. http://www.radanovich.house.gov

Radtke, L.D. and J.L. Turner. 1967. High concentrations of total dissolved solids block spawning migration of striped bass, *Roccus saxatilis*, in the San Joaquin River, California. Transactions of the American Fisheries Society 96: 405-407.

Rosenthal, H. and D. F. Alerdice. 1976. Sublethal effects of environmental stressors, natural and pollutional, on marine fish eggs and larvae. Journal of the Fisheries Research Board of Canada. 33:2047-2065.

Ruelle, R., and K.D. Keenlyne. 1993. Contaminants in Missouri River pallid sturgeon. Bull. Environ. Contam. Toxicol. 50: 898-906.

Ruelle, R. and C. Henry. 1994. Life history observations and contaminant evaluation of pallid sturgeon. Final Report U.S. Fish and Wildlife Service, Fish and Wildlife Enhancement, South Dakota Field Office, 420 South Garfield Avenue, Suite 400, Pierre, South Dakota 57501-5408.

Sherk, J.A. J.M. O'Connor and D.A. Neumann. 1975. Effects of suspended and deposited sediments on estuarine environments. *In*: Estuarine Research Vol. II. Geology and Engineering. L.E. Cronin (editor). New York: Academic Press, Inc.

Skjeveland, Jorgen E., Stuart A. Welsh, Michael F. Mangold, Sheila M. Eyler, and Seaberry Nachbar. 2000. A Report of Investigations and Research on Atlantic and Shortnose Sturgeon in Maryland Waters of the Chesapeake bay (1996-2000). U.S. Fish and Wildlife Service, Annapolis, MD. 44 pp.

Smith, Hugh M. and Barton A. Bean. 1899. List of fishes known to inhabit the waters of the District of Columbia and vicinity. Prepared for the United States Fish Commission. Washington Government Printing Office, Washington, D.C.

Spells, A. 1998. Atlantic sturgeon population evaluation utilizing a fishery dependent reward program in Virginia's major western shore tributaries to the Chesapeake Bay. U.S. Fish and Wildlife Service, Charles City, Virginia.

Squiers, T., L. Flagg, and M. Smith. 1982. American shad enhancement and status of sturgeon stocks in selected Maine waters. Completion report, Project AFC-20.

Squiers, T. And M. Robillard. 1997. Preliminary report on the location of overwintering sites for shortnose sturgeon in the estuarial complex of the Kennebec River during the winter of 1996/1997. Unpublished report, submitted to the Maine Department of Transportation.

Sutherland, David P. 1999. Washington Aqueduct sediment discharges report of panel recommendations. Prepared by Chesapeake Bay Field Office. U.S. Fish and Wildlife Service, 177 Admiral Cochrane Drive, Annapolis, Maryland.

Taubert, B.D. 1980b. Biology of shortnose sturgeon (Acipenser brevirostrum) in the Holyoke Poll, Connecticut River, Massachusetts. Ph.D. Thesis, University of Massachusetts, Amherst, 136 p.

Uhler, P.R. and O. Lugger. 1876. List of fishes of Maryland. Rept. Comm. Fish. MD. 1876: 67-176.

Varanasi, U. 1992. Chemical contaminants and their effects on living marine resources.

pp. 59- 71. in: R. H. Stroud (ed.) Stemming the Tide of Coastqal Fish Habitat Loss. Proceedings of the Symposium on Conservation of Fish Habitat, Baltimore, Maryland. Marine Recreational Fisheries Number 14. National Coalition for Marine Conservation, Inc., Savannah Georgia.

Vinyard, L. and W.J. O'Brien. 1976. Effects of light and turbidity on the reactive distance of bluegill (*Lepomis macrochirus*) J. Fish. Res. Board Can. 33: 2845-2849.

Von Westernhagen, H., H. Rosenthal, V. Dethlefsen, W. Ernst, U. Harms, and P.D. Hansen. 1981. Bioaccumulating substances and reproductive success in Baltic flounder Platichthys flesus. Aquatic Toxicology 1:85-99.

Waters, Thomas F. 1995. Sediment in Streams. American Fisheries Society Monograph 7. American Fisheries Society, Bethesda, MD. Pages 95-96.

Welsh, Stuart A., Michael F. Mangold, Jorgen E. Skjeveland, and Albert J. Spells. 2002. Distribution and Movement of Shortnose Sturgeon (*Acipenser brevirostrum*) in the Chesapeake Bay. Estuaries Vol. 25 No. 1: 101-104.

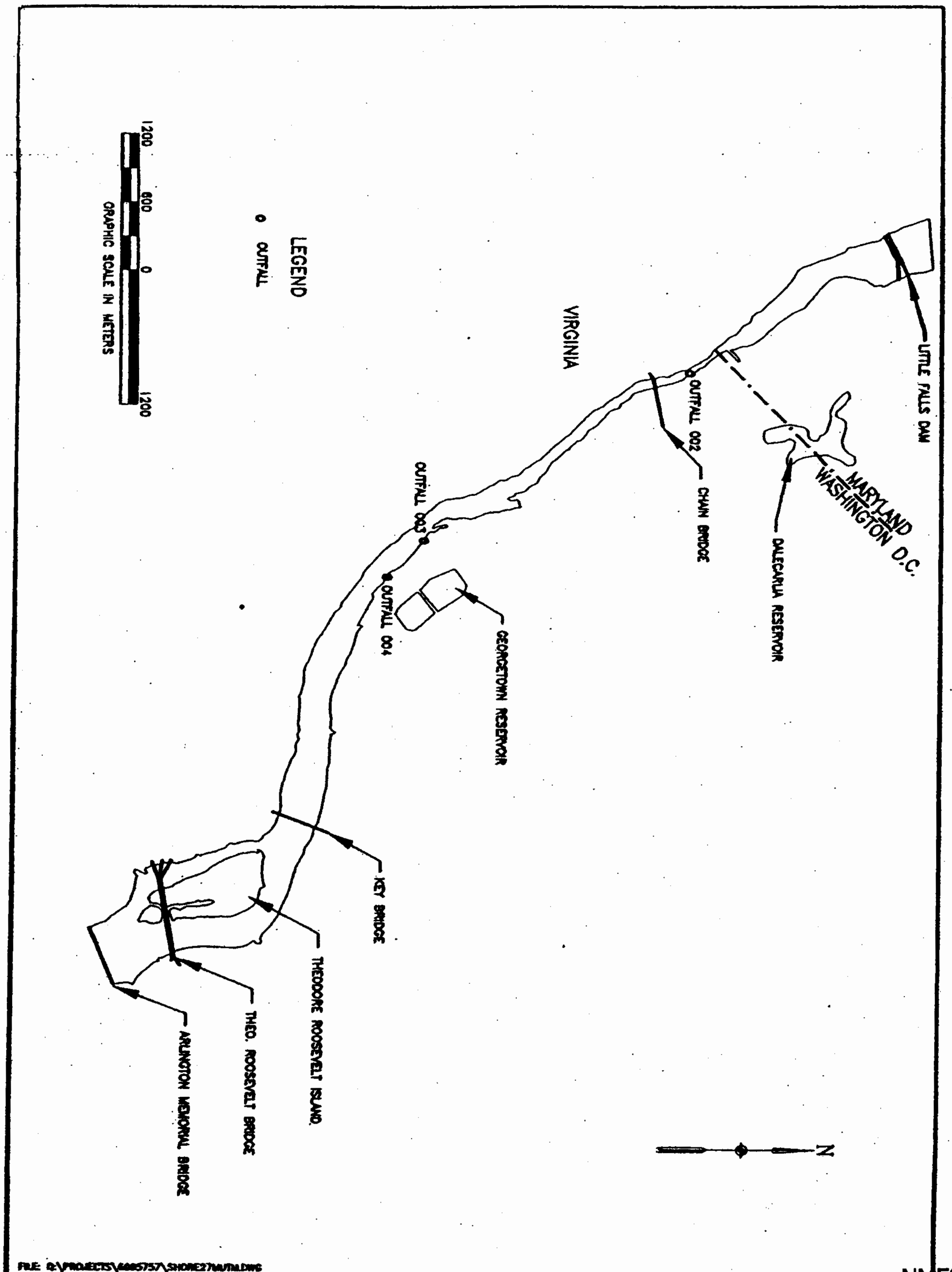
Whitman, Requardt and Associates. 1995. Residuals Thickening and Dewatering Pilot Study – Dalecarlia Water Treatment Plant and Georgetown Reservoir Residuals Disposal Facilities. Technical Memorandum No. 7. Prepared for the U.S. Army Corps of Engineers, Baltimore District. Baltimore, Maryland.

Wilber, Dara H. and Douglas C. Clarke. 2001. Biological Effects of Suspended Sediments: A review of suspended sediment impacts on fish and shellfish with relation to dredging activities in estuaries. North American Journal of Fisheries Management 21:855-875.

APPENDIX A

Map of Project Area

Washington Aqueduct Discharge Outfall Locations



Appendix B

Table 1. Comparison of Plume Characteristics Between Original and Alternate Model Scenarios for Washington Aqueduct Outfalls Under Low Flow Conditions (E.A. Engineering, 2003)

Outfall 002 - 800-mgd Potomac River Flow

TSS (mg/L)	Distance from Outfall (m) Original (a)	Alternate 1 (b)	Alternate 2 (c)
100	120	144	139
20	780	583	538
5	1070	871	837
2	1150	966	941
1	1210	1019	998
Sediment Deposition (mm)			
1.0	190	85	93
0.5	340	235	127

Outfall 003 - 1500-mgd Potomac River Flow

TSS (mg/L)	Distance from Outfall (m) Original (a)	Alternate 1 (b)	Alternate 2 (c)
100	210	234	453
20	570	547	676
5	970	808	893
2	1160	951	1017
1	1270	1050	1098
Sediment Deposition (mm)			
20	62	88	62
5	150	217	96
1.0	280	516	159
0.5	520	595	200

(a) Original model scenario.
(b) Original particle classification with alternate model parameters.
(c) Alternate particle classification with alternate model parameters.